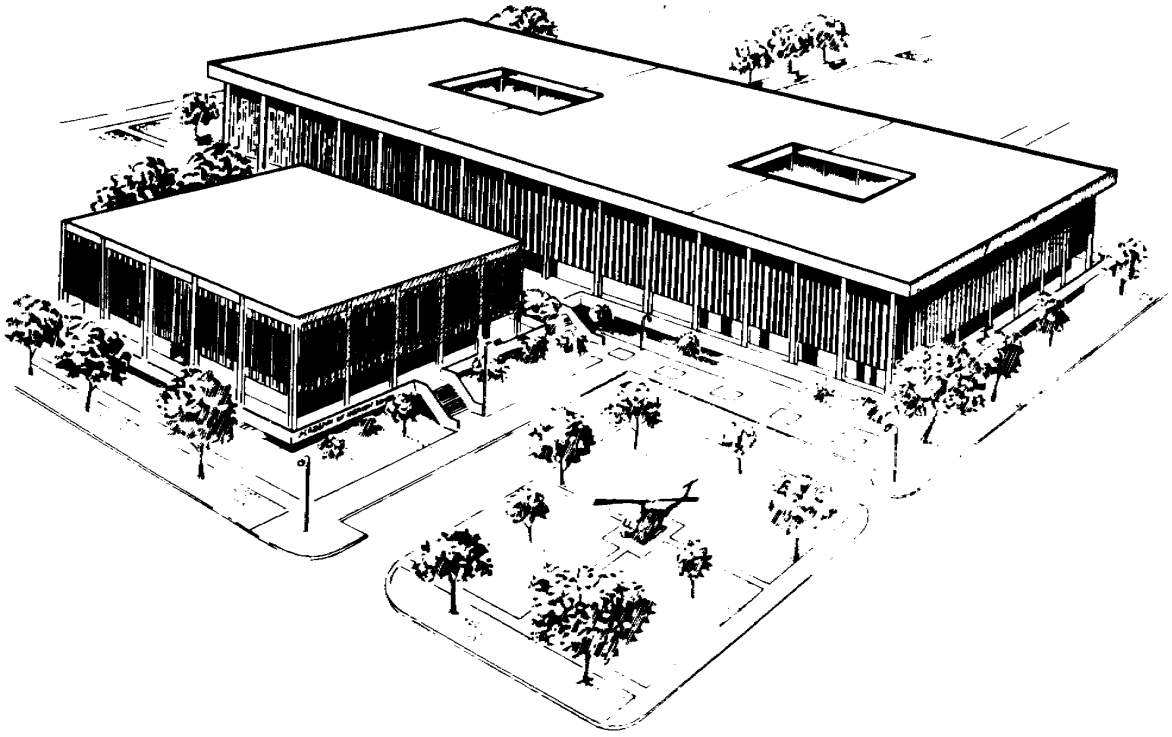
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
FORT SAM HOUSTON, TEXAS 78234-6100



FOOD DETERIORATION

SUBCOURSE MD0723 EDITION 100

DEVELOPMENT

This subcourse is approved for resident and correspondence course instruction. It reflects the current thought of the Academy of Health Sciences and conforms to printed Department of the Army doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

ADMINISTRATION

Students who desire credit hours for this correspondence subcourse must enroll in the subcourse. Application for enrollment should be made at the Internet website: http://www.atrrs.army.mil. You can access the course catalog in the upper right corner. Enter School Code 555 for medical correspondence courses. Copy down the course number and title. To apply for enrollment, return to the main ATRRS screen and scroll down the right side for ATRRS Channels. Click on SELF DEVELOPMENT to open the application; then follow the on-screen instructions.

For comments or questions regarding enrollment, student records, or examination shipments, contact the Nonresident Instruction Branch at DSN 471-5877, commercial (210) 221-5877, toll-free 1-800-344-2380; fax: 210-221-4012 or DSN 471-4012, e-mail accp@amedd.army.mil, or write to:

NONRESIDENT INSTRUCTION BRANCH
AMEDDC&S
ATTN: MCCS-HSN
2105 11TH STREET SUITE 4191
FORT SAM HOUSTON TX 78234-5064

Be sure your social security number is on all correspondence sent to the Academy of Health Sciences.

CLARIFICATION OF TERMINOLOGY

When used in this publication, words such as "he," "him," "his," and "men" 'are intended to include both the masculine and feminine genders, unless specifically stated otherwise or when obvious in context.

USE OF PROPRIETARY NAMES

The initial letters of the names of some products may be capitalized in this subcourse. Such names are proprietary names, that is, brand names or trademarks. Proprietary names have been used in this subcourse only to make it a more effective learning aid. The use of any name, proprietary or otherwise, should not be interpreted as endorsement, deprecation, or criticism of a product; nor should such use be considered to interpret the validity of proprietary rights in a name, whether it is registered or not.

TABLE OF CONTENTS

TABLE OF CONTENTS

CORRESPONDENCE COURSE OF
THE U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0723

FOOD DETERIORATION

INTRODUCTION

Foods undergo deterioration of varying degrees in their sensory characteristics, nutritional value, safety, and aesthetic appeal. Most foods, from the time they are harvested, slaughtered, or manufactured, undergo progressive deterioration that, depending upon the food, may be very slow or so rapid as to render the food virtually useless in a matter of hours. This presents a problem to the Department of Defense because food supplies have to be purchased well in advance of anticipated usage. Large quantities of food are lost each year due to deterioration. The problem is due to the perishable nature of food, as well as to the rather lengthy Defense subsistence supply chain. Due to these factors, veterinary food inspection specialists are tasked with recognizing deterioration in subsistence and making recommendations to preclude public health problems and financial losses to the Government.

Subcourse Components:

The subcourse instructional material consists of six lessons as follows:

Lesson 1, Introduction to Food Deterioration.
Lesson 2, Deterioration of Meat and Meat Products.
Lesson 3, Deterioration of Waterfoods.
Lesson 4, Deterioration of Dairy Products and Shell Eggs.
Lesson 5, Deterioration of Fresh Fruits and Vegeables.
Lesson 6, Deterioration of Semiperishable Subsistence

Here are some suggestions that may be helpful to you in completing this subcourse:

--Read and study each lesson carefully.

--Complete the subcourse lesson by lesson. After completing each lesson, work the exercises at the end of the lesson, marking your answers in this booklet.

--After completing each set of lesson exercises, compare your answers with those on the solution sheet that follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

Credit Awarded:

Upon successful completion of the examination for this subcourse, you will be awarded 10 credit hours.

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Branch at Fort Sam Houston, Texas.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1	Introduction to Food Deterioration.
TEXT ASSIGNMENT	Paragraphs 1-1 through 1-25.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

1-1. Define the following deteriorative terms: food deterioration, food spoilage, adulteration, abnormal, wholesomeness, quality, and serviceability.

1-2. Identify the characteristics evaluated by a sensory evaluation.

1-3. Identify the major causes of food deterioration.

1-4. Identify common deteriorative conditions as to causes, abnormal characteristics, and control.

1-5. Identify possible serviceability recommendations.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 1

INTRODUCTION TO FOOD DETERIORATION

Section I. GENERAL

1-1. IMPORTANCE

a. The Department of Defense (DOD) is concerned about the quality of the foods it procures, transports, stores, and issues. This concern is not unfounded. Of the large quantities being handled, a substantial amount of food has to be disposed of, or special action is taken in order to maintain quality and wholesomeness standards.

b. It is clear that all foods are perishable, regardless of the classification one may have seen for a particular food item. Some foods become unfit for human consumption more quickly than others. Foods are quite unlike hardware such as nuts and bolts. Yet, modern food markets and commissaries with their processed and preserved foods tend to give their customers the impression of similar durability for many food items. This is where the problem begins.

c. Food, from the time it is harvested, slaughtered, or processed, is continually undergoing deterioration. This presents a problem to DOD because food supplies have to be purchased well in advance of anticipated usage. Large quantities of food are lost each year due to deterioration. The problem is caused by the perishable nature of food as well as to the length of the supply chain. Because of these factors, veterinary food inspection specialists are tasked with recognizing deterioration in subsistence and making recommendations to preclude public health problems and financial losses to the government.

1-2. DEFINITIONS

Before any serious discussion of food deterioration, we need to define several terms that are important in understanding food deterioration.

a. **Food Deterioration.** The first term is food deterioration. We define this term as a series of continuous degradative changes occurring in a food item which may affect the product's wholesomeness, result in a reduction of its quality, and/or alter its serviceability.

(1) Deterioration is a continuing process that begins the moment an animal is slaughtered or a plant is harvested and continues until the item is no longer recognizable as a food item or is literally reduced to dust.

(2) Some of the techniques that are used to slow down the continuous changes are freezing, drying, blanching, use of additives, and canning.

(3) As a veterinary food inspection specialist, it is your task to recognize early stages of deterioration before the food items reach the consumer.

b. **Wholesomeness.** Wholesomeness is a term that refers to freedom from pathogenic or otherwise harmful microorganisms. Wholesomeness is a characteristic possessed by a food product that is conducive to good health and well being in the consumer.

(1) Unwholesome. Unwholesome food is food procured, packed, or held under unsanitary conditions that renders it injurious to the health of the consumer, or food or food containers having naturally occurring or added harmful substances, or food found to be filthy, putrid, decomposed, or produced from a diseased animal or an animal that died other than by slaughter.

(2) Off-condition. Off-condition is any variation from the expected appearance, feel, smell, or taste characteristics of a product when it was initially produced or processed for resale. (A product is considered unwholesome if any off-condition affects it in such a way that the product may be injurious to the health of the consumer.)

c. **Quality.** Quality is a term that refers to the degree of excellence or grade of a product. The quality is important in protecting the financial interests of the Government.

d. **Serviceability.** Serviceability is a term that refers to the usefulness of a food item. Reduced serviceability in a product may result in the use of additional processing methods to return the food item to its original state.

e. **Spoilage.** Spoilage is also a term which we often hear in conjunction with deterioration. Often, spoilage is used as a synonym for deterioration. However, we need to make a distinction between these two terms. We define food spoilage as an arbitrary end point of the deterioration process which denotes that a food item is unwholesome and, therefore, is no longer suitable for human consumption.

(1) Spoilage is a result of the deterioration process. We should use the term spoilage as a benchmark--a signal to denote that a food item is unwholesome and is no longer suitable for human consumption.

(2) We know that spoilage can occur anywhere during the deterioration process. The point of spoilage depends upon such factors as type of food (milk vs. beef), storage environment (low-temperature storage vs. high-temperature), and method of preservation (canning vs. freeze dehydration).

f. **Abnormal.** Abnormal is another term that is commonly used in a discussion on deterioration and spoilage. Abnormal is a sensory evaluation term that refers to those characteristics exhibited by a food item, which is judged to differ from the normal characteristics; the food item does not lie within the permissible variations possessed by high-quality like items.

(1) Knowledge of normal characteristics. Determining the normal characteristics of a food item is an important and vital step in the inspection of subsistence. Without knowing normal characteristics, it is very difficult to determine if a product is deteriorated or spoiled.

(2) Permissible variation. An example of the permissible variation possessed by a high-quality like item would be celery. Celery has a range of colors that varies from light to dark green. All of these would be normal for the product. Abnormal colors would be black, purple, or red.

g. **Food Adulteration.** Food adulteration is another term we commonly associate with deterioration. A simple definition of this term is an act or process, either intentional or unintentional, of making a food impure.

(1) Reference. A more complete explanation of what constitutes food adulteration is found in Chapter IV, Section 402, of the Food, Drug, and Cosmetic Act.

(2) Stated meaning. Adulterated shall mean the condition of a food:

(a) If it bears or contains any poisonous or deleterious substance in a quantity which may render it injurious to health.

(b) If it bears or contains added poisonous or deleterious substance for which no safe tolerance has been officially established, or in excess of such tolerance if one has been established.

(c) If it consists in whole or part of any filthy, putrid, or decomposed substance, or if it is otherwise unfit for human consumption.

(d) If it has been processed, prepared, packed, or held under unsanitary conditions, whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health.

(e) If it is in whole or in part, the product of a diseased animal, or an animal which had died other than by slaughter.

(f) If its container is composed in whole, or in part, of any poisonous or deleterious substance that may render the contents injurious to health.

Section II. DETECTION OF DETERIORATION

1-3. SENSORY EVALUATION

As a veterinary food inspection specialist, you are interested in how to detect deteriorative changes in foods. Even though the changes are extremely complex, signs of the changes are easily recognized by the use of sensory evaluation.

a. **All Physical Senses Used.** In most cases, the only equipment the inspector needs to detect deterioration is his physical senses. All senses, including hearing, are used in making a sensory evaluation. Hearing may be used to detect abnormal signs in a canned item by shaking the item. Hearing may also be used to detect the escape of gas from a canned item when opened.

b. **Characteristics Common to Food Items.** Physical senses are used to evaluate the following characteristics of a food item:

(1) Color. Color is an appearance attribute (characteristic) of a food that aids in the identification of its condition. An off-color (abnormal) is indicative of a deteriorative condition. To be considered off-color, the color of the food item must be judged to differ from that of the normal color and the permissible variations possessed by a high-quality like item.

(2) Odor. Odor is a characteristic of a food item that makes it perceptible to the sense of smell. The odor qualities of a food aids in the identification of its condition. An off-odor (abnormal) is indicative of a deteriorative condition. Terms that have been used to describe off-odors are fruity, spicy, burnt, sharp, sweet, rancid, metallic, and others.

(3) Texture. Texture refers to the physical properties of a food that perceived as tenderness or toughness, crispness or softness, and other evaluations. An abnormal texture is indicative for a deteriorated condition. Terms that have been used to describe abnormal textures are water-soaked, slimy, soft, hard, brittle, spongy, and others. If dealing with a liquid product, the term texture is defined to be synonymous with the term consistency.

(4) Taste (flavor). Taste is a comprehensive term used to refer to the four primary sensations (sweet, salty, sour, bitter) and their variations in the mouth. An off-flavor (abnormal) usually offends the senses of taste and smell and is indicative of a deteriorated condition. An off-flavor, however, might also be a pleasant odor which is not characteristic of the product. Terms that have been used to describe off-flavors are fishy, putrid, grassy, sour, musty, and others.

1-4. EVALUATION PROCEDURES

The evaluation procedures that are used in the evaluation of subsistence items are the closed-package inspection and the open-package inspection.

a. **Closed Package.** The term closed package means an inspection of the product's packaging and packing materials, for evidence of a deteriorative condition. The integrity of the food package is not altered during this inspection. After the closed-package inspection, the sample unit can usually be returned to the lot from which it was drawn.

b. **Open Package.** The term open package means an evaluation of a food component for evidence of a deteriorative condition. The inner packaging material (opening the can or cutting the flexible packaging material) is destroyed during the inspection. After inspection, the product usually cannot be returned to its lot since the product or the packaging has been destroyed. Generally, open-package inspection is performed only on products which have been stored longer than is recommended. However, inspections may be made when storage conditions are extremely unfavorable, when isolated lots are inspected, when the inspector suspects internal deterioration, or when he has other important reasons for opening the packages.

(1) Evaluation of vacuum. Prior to opening of the container, an evaluation of vacuum, if applicable, must be made. When the food is processed in a jar or a can, a good vacuum inside the container is desired. A vacuum reduces the strain on the container during heat processing, holds the ends in a collapsed concave position during subsequent storage, and reduces the amount of headspace oxygen. The vacuum is obtained by exhausting with steam or by vacuum sealing. The loss of vacuum (springer formation) is one of the principle types of pack failure. The evolution of gas within the container causes the can ends to become distorted beyond the normal concave position. Gas may be formed either from hydrogen produced by corrosion on the inside of the can by the food product or by microbial action on the food product.

(2) Evaluation of food component. After determining the vacuum, evaluation of the food component is made. Practically all deteriorative conditions affecting the food component manifest themselves as changes from the normal characteristics or attributes of the product, such as a change of color, texture, odor, and/or flavor. These changes may be very pronounced or, at times, they may be very subtle.

(3) Evaluation of internal packaging. In addition to an evaluation of the vacuum and an evaluation of the food component, an evaluation of the internal packaging components must be made. The internal inspection may reveal defects not seen otherwise or may reveal the cause of defects observed during external inspection of the container. Examples of internal defects seen in cans are spangling, detinning, scarred or flaked enamel, pinholing, and flat sour.

Section III. MAJOR CAUSES OF FOOD DETERIORATION

1-5. INTRODUCTION

The point that foods do deteriorate has been adequately made; but what are the causes of food deterioration? There are six major causes of food deterioration--microorganisms, action of enzymes, chemical reactions, physical changes, time, and insects and/or rodents. These causes are not isolated in nature. Bacteria, insects, and light, for example, can all be operating simultaneously to deteriorate food in the field or in a warehouse. Similarly, such causes as high temperature, moisture, and air will all affect the multiplication and activities of bacteria, as well as the chemical and enzymatic activities of the food. At any one time, many forms of deterioration may be in progress, depending upon the food and environmental conditions. Total food preservation, an ideal that can only be approached, requires that we eliminate or minimize all of these causes that may affect a susceptible food.

1-6. MICROORGANISMS

The microorganisms that are principally involved in food deterioration are bacteria, molds, and yeasts. There are thousands of genera and species of microorganisms. Several hundred are associated in one way or another with food products. Not all cause food spoilage, and many types are used in preserving foods, such as the lactic-acid-producing organisms of cheese, sauerkraut, and some types of sausage. Other microorganisms are used for alcohol production as in wine or beer-making, or for flavor production in other foods. However, except where these microorganisms are especially cultivated by selective inoculation or by controlled conditions to flavor their growth over that of less desirable types, microorganism multiplication on or in foods is a major cause of food deterioration. The microorganisms will attack virtually all food constituents. Some will ferment sugars and hydrolyze starches and cellulose. Others will hydrolyze fats and produce rancidity. Still others will digest proteins and produce putrid and ammonia-like odors. Some will form acid and make food sour. Others will produce gas and make food foamy. Some will form pigments, and a few will produce toxins and give rise to foodborne illnesses. When food is contaminated under natural conditions, several types of organisms will be present together. Such mixed organisms contribute to a complex of simultaneous or sequential changes which may include acid, gas, putrefaction, and discoloration.

a. **Bacteria.** Bacteria are unicellular microorganisms of many forms, although three principal shapes of the individual cells predominate. These are the spherical shape represented by several forms of cocci, the rod shape of the bacilli, and spiral forms possessed by the spirilla. Some bacteria produce spores which are remarkably resistant to heat, chemicals, and other adverse conditions. Bacterial spores are far more resistant than yeast or mold spores, and more resistant to most processing conditions than natural food enzymes. All bacteria associated with foods are small. Most are of the order of one to a few microns in cell length and somewhat smaller than

this in diameter. (A micron is one-thousandth of a millimeter (0.001 mm) or about 0.00004 inch.) All bacteria can penetrate the smallest of openings, and many can pass through the natural pores of an egg shell once the natural bloom of the shell is worn or washed away.

b. **Molds.** Molds are larger than bacteria and yeast and more complex in structure. They grow by a network of hair-like fibers called mycelia and send up fruiting bodies that produce mold spores referred to as conidia. The blackness of bread mold and the blue-colored veins of blue cheese are due to the conidia, while beneath the fruiting heads, the hair-like mycelia anchor the mold to the food. The mycelia are a micron or so in thickness and, like bacteria, can penetrate the smallest opening; or in the case of weakened skin or shell can digest the skin and make their own route of penetration.

c. **Yeasts.** Yeasts are somewhat larger than bacteria, of the order of 20 microns in individual cell length and about half this size in diameter. However, yeasts are smaller than molds. Most yeasts are spherical or ellipsoidal in shape. Most yeast cultures are cream, tan, or gray. However, some are yellow, pink, red, green, or brown. Yeasts are associated with nearly all types of food products. Foods such as fresh vegetables, meat, poultry, and cheese often contain yeasts, but in these foods, bacteria outgrow the yeasts. When bacterial inhibitors are added, yeasts can dominate. Some yeasts are found in foods such as honey, molasses, sugar, and fruit. Salt-tolerant yeasts grow as films on brine food and on salted food and ham.

1-7. ACTION OF FOOD ENZYMES

A second major cause of food deterioration is the actions of food enzymes. Enzymes are organic catalysts which are produced by the cells of animals, plants, or bacteria. We know that microorganisms possess enzymes which produce fermentation, rancidity, and putrefaction of foods. Likewise, uninfected food plants and animals have their own enzyme complement, the activity of which largely survives harvest and slaughter. Cereal grains recovered after 60 years of storage have been found to still possess the properties of respiration, germination, and growth--all enzyme controlled functions. Unless these enzymes are inactivated by heat, chemicals, or some other means, they continue to catalyze chemical reactions within foods. Some of these reactions, if not allowed to go too far, are highly desirable, for example, continued ripening of tomatoes after they are picked and natural tenderizing of beef on aging. But ripening and tenderizing beyond an optimum point become food deterioration. The weakened tissues are subject to microbial infections and the deterioration reaches the point of rotting. This can happen in the field, commissary, and home refrigerator, given sufficient time.

1-8. CHEMICAL REACTIONS

Another major cause of food deterioration is chemical reactions. Chemical reactions in foods are sometimes very complex and subtle. Chemical reactions, excluding the action of enzymes, are responsible for such diverse deteriorative changes as oxidation, color changes, reactions between a food container and its contents, and the coagulation of proteins.

a. **Temperature.** We know the rate of deterioration will be significantly influenced by temperature. We can borrow a rule of chemistry (van't Hoff's rule) to estimate the rate at which the deterioration change will take place. In essence, the rule states that for every 18ºF (10ºC) increase in temperature, the rate of a chemical reaction doubles. This rule will suffice for our purposes when we apply it to chemical reactions occurring in foods. Using this general rule, we can say that for every 18ºF (10ºC) increase in storage temperature of a food, the shelf life of the food will be reduced by one half, for the deteriorative chemical reaction rate will have doubled.

b. **Other Causes of Chemical Reactions.** There are many reactions which can lead to the deterioration of food quality or impairment of food safety. Each reaction can involve different reactants or substrates, depending on the specific food and the particular conditions for processing or storage of that food.

1-9. PHYSICAL CHANGES

Physical changes may not cause a food to become spoiled, but they do cause deteriorative changes which may cause the food item to be unsuitable for intended use. Some of the physical changes which cause deteriorative changes in foods are as follows.

a. **Low Temperature.**

(1) Freezing and undesirable changes. Freezing of many foods will cause undesirable changes, such as the destruction of emulsions and texture. Emulsified products, such as salad dressing and mustard, contain a fat/oil and water mixture which does not combine without special processing or additives. If these types of products are frozen, the emulsion will be destroyed and the fat and water will separate into distinct layers. Fruits and vegetables that are allowed to freeze and then thaw will have their texture disrupted. Skins will crack, leaving the food susceptible to attack by microorganisms. The texture of canned fruits and vegetables becomes softened and mushy due to uncontrolled freezing.

(2) Cold damage. Cold damage to foods does not necessarily require the extreme of freezing. Many fruits and vegetables, like other living systems, have optimum temperature requirements after harvest. Held at common refrigeration temperatures of about 41ºF (5ºC), several fruits and vegetables are weakened or killed and deteriorative processes follow. The deteriorations include off-color development, surface pitting, and various forms of decay. Bananas, lemons, squash, and tomatoes are examples of products that should be held at temperatures no lower than 50ºF (10ºC) for maximum quality retention. This provides an exception to the inaccurate generalization that cold storage preserves all foods, and the colder the better.

b. **High Temperature.** There is a moderate temperature range over which much food is handled, such as 50º-100ºF (10º-38ºC). Within this range, for every 18ºF (10ºC) rise in temperature, the rate of chemical reaction is approximately doubled. This includes the rates of many enzymatic as well as nonenzymatic reactions. Excessive heat can denature proteins, break emulsions, dry out foods by removing moisture, and destroy vitamins.

(1) Effect on vegetables. Excessive heat in green vegetables causes cell walls and membranes to lose their integrity and acids and enzymes to be released. All of these result in the development of a soft texture as well as the development of off-colors and off-flavors.

(2) Effect on muscle tissue. The consequences of excessive heat on muscle tissue are that proteins are denatured, the proteins clump together, and enzymes are inactivated. This results in a toughening of the texture, loss of water-holding capacity, cooked or caramel flavors, and development of off-colors.

c. **Dehydration.** Dehydration, another form of physical change that causes food deterioration, can be simply defined as the loss of water from the food product. Foods, especially fresh, chilled, and frozen, are subject to dehydration.

(1) Amount of water in food. Foods contain a substantial amount of water. Meat products contain from 70 to 75 percent water, whereas fresh fruits and vegetables contain from 80 to 95 percent water. Since water vapor is continually seeking to go from an area of high concentration to an area of low concentration, improper storage conditions and improper packaging will result in dehydration. When the humidity is too low in a storage area, dehydration results.

(2) Signs of dehydration. The signs of dehydration include dryness or shriveling on the surface of the food item. The development of off-colors, usually a darkening effect, will also be observed.

(3) Terms used. In frozen foods, the dehydration is known as freezer burn. In fresh fruits and vegetables, it is known as wilt.

d. **Excessive Moisture.** Another form of physical change that causes food deterioration is excessive moisture.

(1) Foods that take in moisture. The gross changes in foods from excessive moisture are part of everyday experience. Dried, dehydrated, and freeze-dried foods are especially susceptible to this form of deterioration. These types of food are very hygroscopic (readily taking up and retaining moisture); if not properly packaged, the product will become lumpy or caked if excessive moisture is present. This condition can possibly lead to other forms of deterioration, such as bacterial growth and chemical reactions such as oxidation.

(2) Effect of surface moisture. Moisture need not be present throughout the food to exert major effects. Surface moisture resulting from slight changes in relative humidity can be a major cause of lumping and caking, as well as surface defects such as mottling, crystallization, and stickiness. The slightest amount of condensation on the surface of the food can become a virtual pool for the multiplication of bacteria or the growth of mold.

(3) Condensation from the food product. This condensation need not come from the outside. In a moisture-proof package, food materials such as fruits and vegetables can give off moisture from respiration and transpiration. This moisture is then trapped within the package and can support the growth of microorganisms.

e. **Mechanical Damage.** The fifth form of physical change is mechanical damage.

(1) Entering point for microorganisms. When an item receives mechanical damage, not only is the appearance of the item affected but the damaged food tissue also becomes more susceptible to other forms of deterioration. Mechanically damaged foods are more susceptible to invasion by microorganisms, for the damaged area serves as a port of entry.

(2) Starting point for enzyme activity. The cell walls of foods are also destroyed by mechanical abrasion, and the inherent enzymes in the food product are liberated from the cells. Once liberated, the enzymes begin the process of deterioration or, more specifically, autolysis. The changes noted would be a softening in the texture, development of off-colors, and development of off-flavors.

f. **Light.** Light, another form of physical change that causes food deterioration, can cause fading of color in many food items. Some vitamins are destroyed by light, notably riboflavin, vitamin A, and vitamin C. Milk in bottles exposed to the sun develops "sunlight" flavor due to light induced fat oxidation and changes in the protein.

(1) Importance of type of light. Not all wavelengths making up natural or artificial light are equally absorbed by food constituents, nor are they equally destructive. Surface discolorations of sausages and meat pigments are different, depending upon the natural light and fluorescent light that may be encountered in display cases.

(2) Control techniques. Sensitive foods often can be protected from light by impervious packaging or by incorporating compounds into glass and transparent films that screen out specific wavelengths. A related problem has to do with maintaining the true color of inks used to depict products in food advertising and on food product labels.

(3) Greening of potatoes. Another problem due to light is the greening of potatoes. This condition is also referred to as sunburn. It is the result of the exposure of the potatoes to sunlight during growth or after digging, and to artificial light during display for sale. After exposing for two days or longer to either natural or artificial light, a green pigment develops. The skin and the flesh are affected. Chlorophyll and an alkaloid called solanine are produced due to exposure to light. The green tubers acquire a bitter, pungent taste. If eaten in quantity, they may be poisonous. Solanine is the bitter and poisonous component. Chlorophyll is tasteless and harmless.

1-10. TIME

Another major cause of food deterioration is that of time or the aging process.

a. **Peak Time for Quality.** After slaughter, harvest, or food manufacture, there is a time when the quality of food is at its peak, but this is only a transitory period. The growth of microorganisms, destruction by insects, action of food enzymes, nonenzymatic interaction of food constituents, loss of flavor, effects of heat, cold, moisture, oxygen, and light, all progress with time. The longer the time, the greater the destructive influences.

b. **The Goal of Maintaining Freshness**. It is true that certain cheeses, sausages, wines, and other fermented foods are improved with aging up to a point. However, for the vast majority of foods, quality decreases with time, and the major goal of food handling and preservation practices is to capture and maintain freshness.

c. **Storage Life.** Time is considered an important cause of food deterioration, for all foods have a definite storage life. The storage life is determined to a great extent by type of food, method of processing, method of packaging, and storage environment. However, the longer a food is stored, the greater is the opportunity for deteriorative changes to occur. This is the rationale behind the frequencies of cyclic inspections of food items.

1-11. INSECTS AND RODENTS

The final major cause of food deterioration is insects and rodents.

a. **Insects.** Insects are particularly destructive to cereal grains and to fruits and vegetables. Both in the field and in storage, it has been estimated that insects destroy 5 to 10 percent of the United States (US) grain crop annually. In some parts of the world, the figure may be in excess of 50 percent.

(1) Opening for decay. The insect problem is not just one of how much an insect can eat, but when insects eat, they damage the food and open it to bacteria, yeast, and mold infection. A small insect hole in a melon, not so bad in itself, can result in the total decay of the melon from bacterial invasion.

(2) Control by use of chemicals. Insects are generally controlled in grain, dried fruits, and spices by fumigation with such chemicals as methyl bromide, ethylene oxide, and propylene oxide. The use of these latter two fumigants frequently is prohibited with foods high in moisture because of the possible formation of toxic substances.

(3) Insect eggs. Insect eggs may persist or be laid in the food after processing, as for example in flour.

b. **Rodents.** The problem with rodents is not only the quantity of food they consume, but also the filth with which they contaminate foods. Rodents' urine and droppings may harbor several kinds of disease-causing bacteria. Rodents can be directly or indirectly involved in the transmission of such diseases as salmonellosis, leptospirosis, and murine typhus. One rat pill, or fecal dropping, can contain several million bacteria. Even if the pill does not get into food directly, it will become dry and fall apart or be crushed. The particles then may be blown or carried into food.

c. **Control of Insects and Rodents.** Insects and rodents may be effectively controlled by following three rules.

(1) Keep insects and rodents out of facilities by pest-proofing the building.

(2) Deprive pests of food and shelter by following good housekeeping practices.

(3) Use appropriate control measures to exterminate pests.

Section IV. DETERIORATIVE CONDITIONS

1-12. INTRODUCTION

Food is a very complex item composed of many substances, some of which are carbohydrates, proteins, fats, water, minerals, vitamins, emulsifiers, stabilizers, antioxidants, and many others. It is the combination of these components which makes one food different from another. Also, each of these components is susceptible to a different form of deterioration, and the changes are subtle and complex. Realizing these facts, there are several deteriorative conditions that are commonly found by the veterinary food inspection specialist during inspection of subsistence items.

1-13. FREEZER BURN

Freezer burn is a deteriorative condition commonly found in frozen foods, especially poultry, waterfoods, and red meats. This condition is a physical change in the food item that results in no loss of wholesomeness. However, a reduction in quality of the product and a reduced serviceability does occur.

a. **Abnormal Characteristics.** The abnormal characteristics that are exhibited by a freezer-burned product include an abnormal color, usually white or pale amber. The surface of the product will be dry and shriveled, and usually there is a buildup of frost on the surface of the product. This texture is similar to that of a dry sponge. A dry, tasteless, stale product is the result of the deteriorative process.

b. **Cause of Freezer Burn.** Freezer burn is caused by the evaporation (sublimation) of moisture from the surface of the food item which results in the product having a bleached, unattractive appearance and adverse effects on the palatability.

(1) Cause of dehydration. Water vapor always seeks to go from an area of high concentration to an area of low concentration. In a freezer, the relative humidity is relatively low because the cold dense air is not capable of holding much moisture. However, the moisture content of the food may be from 65 to 90 percent, depending upon the type of food. This uneven concentration of moisture makes frozen foods very susceptible to moisture loss. Therefore, products which are improperly wrapped and packaged will be susceptible to dehydration. Freezer burn will result.

(2) Cause of color change. While the buildup of frost on the outside of the product is caused by the excessive loss of moisture, the color change is caused by small holes or voids formed in the item. These holes or voids cause the light to be reflected differently. Therefore, the color changes. The small holes also cause the product to be more susceptible to the oxidative process; there is an increased area of exposure to oxygen.

c. **Control.** Freezer burn may be prevented by a skintight covering or an ice glaze for the food product. The skintight covering may be obtained by the use of water-impermeable films, dip coatings, or spray coatings.

d. **Summary.** The deteriorative process, freezer burn, may be summarized by the following.

Frozen Food			
+ Poor Packaging	➡	Loss of Moisture	➡ Freezer Burn
+ Low Relative Humidity			

1-14. RANCIDITY

Rancidity is a term generally used to denote unpleasant odors and flavors in foods resulting from deterioration in the fat or oil portion of a food. Three different mechanisms of rancidity may occur. These are oxidative, hydrolytic, and ketonic.

a. **Oxidative Rancidity.** Oxidative rancidity arises from the decomposition of peroxides. Peroxides are the result of the oxidation of unsaturated fats. The products resulting from the decomposition of peroxides include aldehydes, ketones, and hydrocarbons. These help to produce the flavors and odors associated with oxidative rancidity.

(1) Abnormal characteristics. The abnormal characteristics of a product that has undergone oxidative rancidity are a paintlike or acrid (burning) odor and an abnormal (rancid) taste. The color of a food item is not normally changed due to this deteriorative process. An exception to this occurs in waterfoods; a yellowish-brown discoloration results from the oxidative rancidity process. The texture of a food product is not affected by the deteriorative condition.

(2) Unsaturated fatty acids . All foods containing unsaturated fatty acids (UFA) are susceptible to oxidative rancidity.

(a) The rates of formation and intensities of unpleasantness produced depend upon three factors. These are the composition of the lipid components, their location in the food, and the conditions of storage. In general, high concentrations of UFA, especially acids with three or more double bonds, and exposure to air at elevated temperatures result in rapid development of intense rancidity.

(b) In poultry and fish, rancidity in the skin exceeds that in the flesh. In red meats (frozen or dehydrated), rancidity is more intense in the lipids of the cells than in the fats of the adipose or connective tissue. Frozen stored fatty foods rarely exhibit rancidity upon thawing, but usually develop rancid odors and flavors upon cooking.

(c) At low temperatures, peroxide decomposition is extremely slow, whereas at high temperatures, it is rapid.

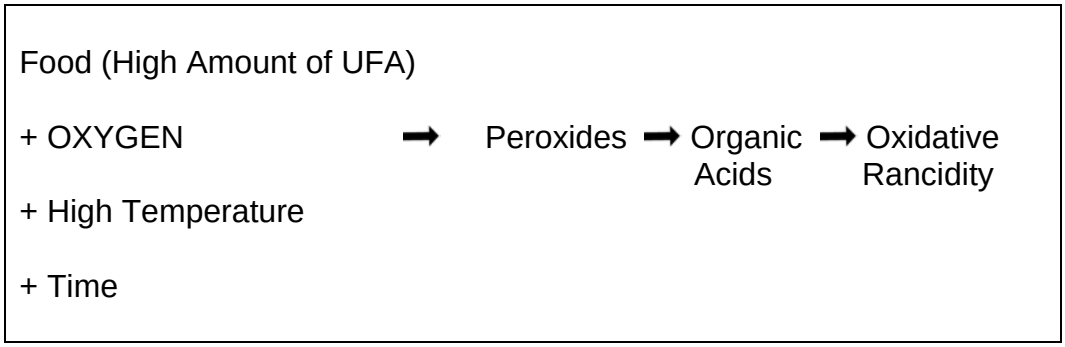
(3) Control techniques. Oxidative rancidity can be retarded by packaging in the absence of oxygen and by the addition of antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate, tocopherols (naturally occurring but also added as vitamin E), and others.

(a) Antioxidants are usually more efficient when added to a fatty ingredient than when added to an intact food.

(b) Incorporation of antioxidants in packaging material in contact with fried snack foods and ready-to-eat cereals has been helpful in retarding oxidative rancidity in these products.

(c) Other factors that slow the rate of this chemical reaction are the use of shorter storage times and the use of low-temperature (freezing) storage.

(4) Summary. Oxidative rancidity may be summarized by the following. diagram:



b. **Hydrolytic Rancidity.** Hydrolytic rancidity is the second type of rancidity. It results from the splitting of fatty acids from their glycerol esters.

(1) Release of free fatty acids. This lipolysis requires the presence of water. It may be mediated by heat, acidity, alkalinity, or lipolytic enzymes. These lipolytic enzymes may be native to the food or introduced by microorganisms. From dairy fats, the hydrolytic release of butyric, caproic, and caprylic acids produces odors which are usually described as goaty. Hydrolysis of coconut and other lauric-acid-containing fats releases principally capric and lauric acids, which produce a soapy taste. When warm, the odor resembles hot buttered popcorn. It is the free fatty acids that produce the odors resulting from hydrolytic rancidity.

(2) Control. Prevention of hydrolytic rancidity requires the use of fully refined oils, careful processing to ensure the inactivation of lipolytic enzymes, and packaging and storage to prevent the introduction of fat-splitting microorganisms.

(3) Special problem areas. Lipolytic rancidity continues to be a problem, especially in confections containing coconut fats or contaminated spices.

c. **Ketonic Rancidity.** The final type of rancidity is ketonic rancidity. It results from the growth of microorganisms among whose metabolic products are odorous methyl ketones. In coconut oils, mold growth, requiring moisture and a nitrogenous nutrient, produces ketones, presumably by beta-oxidation. The resultant odor is said to resemble Roquefort cheese. Hydrolysis also occurs, releasing free fatty acids which impart a soapy taste.

1-15. SOUR ODOR

Sour odors may be detected in several different types of food. In some foods, a sour odor may be normal and desirable, as in sour cream, buttermilk, and other products. However, in many products, a sour odor is undesirable. This condition may be described as an uncontrolled reaction which results in the formation of an abnormal sour odor and flavor. Any food with a high moisture content is susceptible to the development of a sour odor and flavor. Examples of products where a sour odor and flavor is undesirable are large cuts of meats, sausages, dairy products, and many types of canned products.

a. **As Indicator of an Unwholesome Product.** The abnormal characteristics exhibited by a product that has undergone sour-odor development include the formation of sour odor and sour flavor. The odor of the product is not normally affected until the sour odor condition has progressed to an unwholesome phase. Texture may not be affected until latter stages of the deterioration of the product.

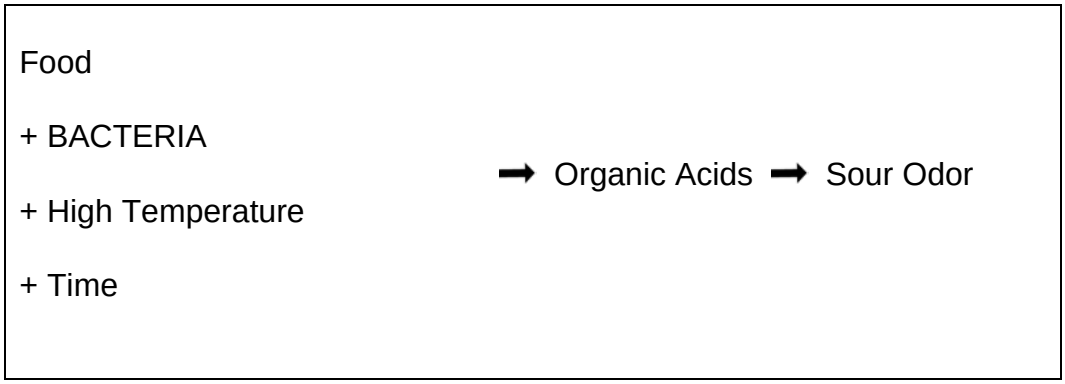
b. **Cause of Sour Odors and Flavors.** Sour odors and flavors are produced by the growth of bacteria in a microaerophilic environment. The bacteria involved are relatively thermal-tolerant lactic acid bacteria, usually lactobacilli.

(1) The bacteria ferment the sugars in the food, which are used as a food source. As the bacteria grow in the food item, they produce as a by-product of their metabolic activities various organic acids, such as formic, acetic, and butyric.

(2) These organic acids are deposited in the food items, where they cause a lowering of the pH of the product. As the pH is lowered, the product develops a sour odor because of the shift toward the acid side of the pH scale.

c. **A Result of Underprocessing.** Cured meats sometimes develop sour odors and flavor several days after processing. This is invariably the result of underprocessing, followed by growth of the surviving microorganisms. The microorganisms involved are relatively thermal-tolerant lactic acid bacteria, usually lactobacilli. These bacteria ferment the sugars in the cured meats with a consequent lowering of the pH of the product. This type of spoilage is more common in the larger sausages, as well as in hams, and can be controlled by the same procedures recommended for the prevention of green cores in sausages.

d. **Summary.** Sour odor may be summarized by the following diagram.



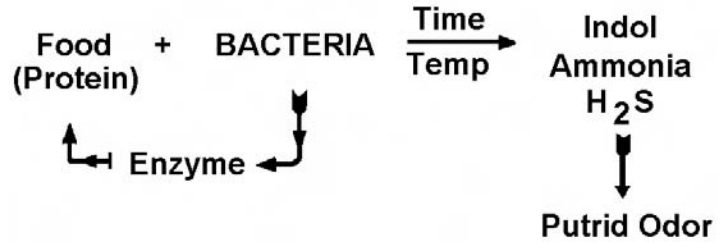
1-16. PUTRID ODOR

Putrid odors are found most commonly in large cuts of meats. The putrid odor is very offensive. Many describe the odor as being foul or tainted. You, the veterinary food inspection specialist, should be aware that a foul odor is characteristic and desirable in certain products, such as Limburger cheese.

a. **Abnormal Characteristics.** In addition to the putrid odor, abnormal characteristics of affected items include a putrid flavor and changes in the texture and color of the product. A darkening effect on the product will be seen in the development of the putrid-odor condition. A softening of the texture, resulting in a mushy product, accompanies the formation of putrid odor.

b. **Cause.** The putrid odor is caused by the anaerobic decomposition of protein by bacteria, mainly the Clostridium species. The bacteria cannot utilize proteins as they are found in a food source. Therefore, the bacteria secrete an enzyme which breaks the protein into simpler compounds, such as indole, hydrogen sulfide, ammonia, and free amino acids. The bacteria cell wall is then able to utilize these compounds as food. Since many of these compounds are very odoriferous, they give the characteristic putrid odor.

c. **Summary.** Putrid odor may be summarized by the following diagram.



1-17. ENZYMATIC DEGRADATION

a. **Results of Enzyme Action.** Deterioration of foods resulting from the catalytic action of enzymes is easy to observe.

(1) An example is the ripening process of the banana wherein it becomes sweeter, softer, less astringent in taste, and more odorous. One of the reactions in this process is the hydrolysis (degradation) of the starch (essentially tasteless and insoluble in the water of the banana) to simple water-soluble sugars.

(2) Another example is the overripe tomato. Here the softening is due largely to the hydrolysis of the pectins to their simpler carbohydrate building blocks. Pectin is a water-soluble carbohydrate found in ripe fruits and has strong gelling properties which are used in cooking.

b. **Changes in Proteins and Fats.** Proteins in such foods as cheese, meat, and fish may be hydrolyzed to simpler compounds by the enzymes naturally present. Fats in some foods may also be hydrolyzed by naturally present enzymes. Such chemical changes are often manifested as changes in taste, odor, texture, and so forth.

c. **Oxidative Enzymes.** When freshly harvested products are processed for eating, the normal cellular organization of the tissues may be disrupted, with the result that residual enzymes may initiate degradative changes at a very rapid rate. One of the most common examples of such changes is the rapid darkening of freshly peeled potatoes, apples, peaches, and pears. Here the oxidative enzymes of the freshly exposed tissues use oxygen from the air to change many naturally occurring colorless compounds (phenols) to colored compounds (quinones). Other oxidizing enzymes induce the common and sometimes intense "hay" flavor of vegetables such as lima beans, corn, and broccoli if they are not cooked soon enough after harvesting.

d. **Control by Heating.** Chemical reactions catalyzed by enzymes can be stopped by destroying or removing the enzymes. The method is simply heating or cooking food. All enzymes are proteins, and proteins are easily changed or denatured by heating. The temperature required to inactivate most enzymes are in the range of 60º-80ºC (140º-176ºF), although some enzymes are destroyed below 60ºC (140ºF) and some require heating to temperature above 80ºC (176ºF) before they lose their catalytic properties.

e. **Control by Freezing.** Many foods are preserved by freezing. However, freezing does not destroy most enzymes, and many frozen foods can deteriorate enzymatically, even though the rates of the reactions may be slowed. Vegetables are the worst offenders. So, in order to preserve peas, green beans, corn, and so forth, by freezing, it is first necessary to heat them briefly to almost 100ºC (212ºF) before they are frozen to prevent deterioration in frozen storage.

f. **Control Techniques for Fruit.** Generally, fruits do not require such heat treatment (blanching), which is fortunate, since many of them are adversely altered in flavor when heated. However, enzymatic darkening often occurs in frozen fruits such as sliced peaches. To counteract this, they are often packed with sugar syrups containing ascorbic acid or similar oxidation inhibitors (antioxidants). Along with proper packaging, this diminishes greatly the amount of atmospheric oxygen reaching the fruit, which is necessary for the darkening reactions.

1-18. NONENZYMATIC BROWNING

a. **Caused by Sugars.** Nonenzymatic browning is a process in which foods darken without the catalytic effect of enzymes. It differs markedly from the darkening of fresh fruits and vegetables due to enzymatic degradation. The food constituents responsible are certain simple sugars which react with proteins, amino acids, or other substances normally present in the foods.

b. **Flavor Change in Some Foods.** Although the darkening in color of the food may be undesirable, the more notable changes are often those of flavor.

(1) The rate of browning reactions increases with temperature, and these chemical changes may contribute to desirable flavor development on cooking.

(2) Maple syrup gets its characteristic flavor from the chemical process as the maple sap is concentrated by boiling.

(3) A similar reaction causes the caramelized flavor in canned evaporated milk, which many people find much less acceptable than the taste of fresh milk. But the same flavors of evaporated milk are characteristic of the desirable flavors of caramel candy and certain other foods.

c. **Limiting Factor for Dehydrated Foods.** Nonenzymatic browning may occur in dehydrated foods (such as meat, eggs, and some fruits and vegetables) after storage for a time. This browning reaction makes dehydrated items objectionable, so much so that this otherwise promising method of food preservation is extremely limited in its practical uses.

d. **Problem in Long-Term Storage.** Nonenzymatic browning is most troublesome in foods, even canned sterilized foods stored for long periods of time at relatively high temperatures. Consequently, food deterioration due to nonenzymatic browning is a great problem in military and survival rations, which are often stored at relatively high temperatures. Although, in a few instances, the browning reaction can be delayed by certain food ingredients, the best way to diminish nonenzymatic browning is proper food processing and storage conditions.

1-19. STALING

Staling is a rather general term applied to a variety of chemical deteriorative changes. Staling is usually manifested as adverse alterations of taste, odor, and texture in prepared foods which are not promptly eaten. The changes may lead to rejection of stale food even though it may not be altered nutritionally.

a. **Control Techniques.** All of the changes are related to the fact that foods are composed of many substances that are chemically altered by heating. Many of the new compounds formed by heating are unstable and react in time with oxygen from the air or with other chemical compounds present in the food. To prevent such changes, many commercially processed foods are heated and stored in the absence of oxygen, for example, canned foods. Another way of excluding most of the oxygen in frozen or refrigerated foods is to have the food covered with sauce or some other liquid and packaged in a container with little residual air.

b. **Bread as an Example.** The staling of bread and related products is familiar to everyone. Furthermore, no better example of food can be found to illustrate the changes in both flavor and texture so typical of the staling process.

(1) Desirable flavors in bread and many other foods result from crust formation. For the purpose, the surface of the food, particularly during baking, is subjected to temperature above the boiling point of water. The heat causes intensified breakdown of food constituents.

(2) Upon standing, even in packages which allow no water loss, bread will degenerate in flavor and become harder and crumbly in texture. This latter change is not due to drying out but to rearrangements of the molecules of water, starch, and protein in the bread itself.

(3) Certain substances can retard the rate of the hardening which takes place during the staling of bread. These materials are emulsifying agents which are used as "freshness preservers."

1-20. SURFACE SLIME

a. **Common on Food Products with High Moisture Content.** Surface slime is found on the surfaces of (or within) food products which have a high moisture content. Slime can be found on meat products, fresh fruits and vegetables, waterfoods, and various other foods. The surface of product will be "slippery" to the touch. The veterinary food inspection specialist should be aware that early stages of slime formation may not be readily recognizable. It may be frequently mistaken for a film of surface fat. As a general rule, however, an off-odor is detected before the "slime" can be physically detected.

b. **Cause of Surface Slime.** Surface slime is caused by the growth of bacteria, mainly of the lactic acid type which includes Lactobacillus, Leuconostoc, Streptococcus, and Pseudomonas. The slime is actually billions of bacteria on the surface of the product and is not a metabolic product of the microorganisms. All of the causative bacteria are able to grow at refrigerator temperatures on the moist surfaces of the food item.

c. **Visible Slime.** The time interval for the onset of visible slime is dependent upon the amount of initial surface contamination, the holding temperatures of the food, and the amount of surface moisture.

1-21. SUMMARY OF DETERIORATION

The major modes of deterioration in various products are summarized in figures 1-1 and 1-2. Also listed in this figure is a list of critical environmental factors that play an important role in the deterioration of food items.

1-22. OTHER CONDITIONS

There are several conditions in food products that may be confused with deterioration but present no potential health hazard.

a. **Struvite Crystals.** Small crystals of a harmless chemical substance, magnesium ammonium phosphate (also referred to as struvite), often gradually form in fish and shellfish packs. The constituents of these crystals are necessary for normal health. They cause no harm if swallowed. However, the crystals are often mistaken for glass and thus are undesirable. Their formation may be reduced or eliminated by the addition of certain chemicals to waterfoods prior to canning. Struvite crystals are commonly seen in cans of tuna and salmon.

PERISHABLES	MODE OF DETERIORATION (Assuming an Intact Package)	CRITICAL ENVIRONMENTAL FACTORS
Fluid milk and dairy products	Bacterial growth, oxidized flavor, hydrolytic rancidity	Oxygen, temperature
Cheese	Rancidity, browning, lactose crystallization, undesirable mold growth	Temperature, relative humidity
Ice cream	Graininess cause by ice or lactose crystallization, texture	Fluctuating temperature (below freezing)
Fresh red meat	Bacterial growth, loss of red color	Oxygen, temperature, light
Fresh poultry	Bacterial growth, off-odor	Oxygen, temperature, light
Fresh fish	Bacterial growth, off-odor	Temperature
Fresh fruits and vegetables	Respiration, compositional changes, nutrient loss, wilting, bruising, microbial growth	Temperature, relative humidity, light, oxygen, physical handling
Frozen meats, poultry, fish	Rancidity, protein denaturation, color change, desiccation (freezer burn), toughening	Oxygen, temperature, temperature fluctuations
Frozen fruits and vegetables	Loss of nutrients, loss of texture, flavor, odor, color, and formation of package ice	Oxygen, temperature, temperature fluctuations
Frozen concentrated juices	Loss of cloudiness, yeast growth, loss of vitamins, loss of color or flavor	Oxygen, temperature, temperature fluctuations
Frozen convenience foods	Rancidity in meat portions, weeping and curding of sauces, loss of flavor, loss of color, package ice	Oxygen, temperature, temperature fluctuations

Figure 1-1. Major modes of deterioration, perishables.

SEMIPERISHABLES	MODE OF DETERIORATION (Assuming an Intact Package)	CRITICAL ENVIRONMENTAL FACTORS
Fresh bakery products	Staling, microbial growth, moisture loss causing hardening, oxidative rancidity	Oxygen, temperature, humidity
Breakfast cereals	Rancidity, loss of crispness, nutrient loss, breakage	Relative humidity, temperature, rough handling
Pasta	Texture changes, staling, vitamin, and protein quality loss, breakage	Relative humidity, temperature, light, oxygen, rough handling
Fried snack foods	Rancidity, loss of crispness, breakage	Oxygen, light, temperature, relative humidity, physical handling
Dehydrated foods	Browning, rancidity, loss of color, loss of texture, loss of nutrients	Relative humidity, temperature, light, oxygen
Nonfat dry milk	Flavor deterioration, loss of solubilization, caking, nutrient loss	Relative humidity, temperature
Coffee	Rancidity. loss of flavor and odor	Oxygen, temperature, lights, relative humidity
Tea	Loss of flavor, absorption of foreign odors	Oxygen, temperature, light, humidity
Canned fruits and vegetables	Loss of flavor, texture, color, and nutrients	Temperatures

Figure 1-2. Major modes of deterioration, semiperishables.

b. **Tartrate (Argol) Crystals.** These crystals precipitate (clump together) readily from grape juice in storage. These crystals, commonly called argol, are not harmful, but are often mistaken for glass. Thus, the crystals are undesirable. The crystals are normally removed during the normal processing procedures by filtering.

c. **Tyrosine Deposits.** Tyrosine occasionally forms a whitish deposit on many foods, chiefly noted on Swiss cheese. However, it also forms on herring and anchovy packs, bacon, ham, and sausages. This amino acid, due to its low solubility, precipitates when migrating to the surface.

(1) In Swiss cheese, tyrosine crystals appear in the holes. Their occurrence is due to certain conditions in the manufacture of the cheese.

(2) In the case of canned herring, the whitish patches appear only in the bottom of the can, since the brine must be in free contact with the fish surface.

(3) Lengthy storage is necessary for this change to occur in bacon and dry sausages (salami and pepperoni), although the exact conditions have not yet been established.

d. **Calcium Lactate Deposits.** White specks occurring on any type of matured cheese have been identified as calcium lactate, with or without tyrosine crystals. The whitish deposits are easily observable in rindless cheeses. The rind of conventional cheese evidently masks the visual signs of this crystallization. Cheese in flexible packages is more prone to surface crystallization. Any excessive handling or moisture losses initiate crystal formation.

Section V. DISPOSITION RECOMMENDATIONS

1-23. BASIS OF RECOMMENDATIONS

After the condition of a product is determined, a recommendation for the disposition of the item has to be made. The recommendation should be based on the following considerations.

a. **How Serious is the Defect?** The seriousness of the defect has a great effect on the recommendation. If the wholesomeness of the product is affected, a certain recommendation may be made, whereas if only the serviceability is affected, then another recommendation may be made.

b. **How Rapidly Will the Product Deteriorate?** The shelf life of the product remaining will affect the recommendation to be made.

c. **How Much Time Will Elapse Before Consumption of the Food Item?** The type of food item also greatly affects this consideration.

1-24. GUIDELINES FOR ACTION

Recommendations should always be provided in writing. They are, of course, expected to be both concise and reasonable. If the recommendations meet these criteria, then the veterinary food inspection specialist is protected, the accountable officer is prevented from forgetting, additional irritation and complaints are avoided, and further loss of the product is usually prevented.

1-25. POTENTIAL RECOMMENDATIONS

The following subsistence disposition recommendations may be used by the veterinary food inspection specialist.

a. **Normal Issue.** The product has no, or very little, deterioration present and can be handled and used in the manner for which it was procured.

b. **Rework, Repack, Recoup.** The product or food item has deterioration present but part of the product is still serviceable or useable. Remove the deteriorated product from the lot, consolidate the good into another lot, and issue that useable lot.

c. **Overissue.** The product has deterioration present. The percent loss or deterioration is determined by the veterinary food inspection specialist. The accountable officer will issue more product than requested to compensate for the percent deterioration or loss. The amount of overissue will equal the percent loss.

d. **Issue by (Date).** The product shows signs of deterioration. The veterinary food inspection specialist will estimate the remaining shelf life and recommend issue by this date.

e. **Consume by (Date).** This product also shows signs of deterioration. The veterinary food inspection specialist estimates the remaining shelf life and then recommends consumption of the product by this date.

f. **Hold.** A determination on the condition of the product is made. In the course of the inspection, it is found that the product needs to be sent either to the laboratory for testing and analysis or held for further inspection. Therefore, the product is suspended from issue.

g. **Condemn.** The product is found to be unfit for human consumption or for its intended purpose. The item will be disposed of through accepted local channels according to unit standing operating procedures (SOP).

h. **Issue Locally.** The product is not suitable for shipment. The item must be utilized locally and a like product, that is in better condition, must be shipped.

i. **Priority Issue.** This recommendation is applicable to DPSC perishable subsistence. This term indicates a decrease in serviceability. The product is to be issued as soon as possible.

NOTE: Other terms may be listed in documents pertaining to specific situations. The terms "Issue by (date)" and "Consume by (date)" allow the accountableofficer to use any method he desires to move the product.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or by completing the incomplete statement or by writing the answer in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each incorrect answer, reread the material referenced after the answer.

1. Define food deterioration.

_____

_____

_____

2. Define food spoilage.

_____

_____

_____

3. Define abnormal.

_____

_____

_____

_____

4. Define quality.

_____

_____

5. Define wholesomeness.

_____

_____

6. Define serviceability.

_____

7. Define adulteration.

_____

8. The physical senses are used to evaluate four characteristics of a food item. The four characteristics are:

   a. _____.

   b. _____.

   c. _____.

   d. _____.

9. Define closed-package inspection.

_____

_____

_____

10. Define open-package inspection.

_____

_____

11. The six major causes of food deterioration are:

    a. _____.

    b. _____.

    c. _____.

    d. _____.

    e. _____.

    f. _____.

12. The chemical compounds that are formed or produced in potatoes due to exposure to light are _____ and _____.

13. Describe the following abnormal characteristics of freezer burn:

    Color _____.

    Texture _____.

    Taste _____.

14. The color change in freezer burn is due to _____ and _____ causing the light to be _____ differently.

15. The three types of rancidity and their causes are:

    a. _____.

    b. _____.

    c. _____.

16. Sour odors and flavors are due to _____.

17. Fluid milk and dairy products are subject to several modes of deterioration. Three modes of deterioration are:

    a. _____.

    b. _____.

    c. _____.

18. Cheese varieties are subject to several modes of deterioration. Four modes of cheese deterioration are:

    a. _____.

    b. _____.

    c. _____.

    d. _____.

19. Frozen meats, poultry, and fish undergo several modes of deterioration. Four of those modes are:

    a. _____.

    b. _____.

    c. _____.

    d. _____.

20. Dehydrated foods are subject to several modes of deterioration. Four of those modes are:

    a. _____.

    b. _____.

    c. _____.

    d. _____.

21. Canned fruits and vegetables are subject to several modes of deterioration. Four of those modes are:

    a. _____.

    b. _____.

    c. _____.

    d. _____.

22. Select the recommendation where the percent loss or deterioration is determined by the veterinary food inspection specialist.

    a. Priority issue.

    b. Rework, repack, recoup.

    c. Overissue.

    d. Hold

23. Select the recommendation that indicates a decrease in serviceability (as applied to perishable subsistence).

    a. Priority issue.

    b. Issue locally.

    c. Consume by (date).

    d. Issue by (date).

24. There are conditions that are confused with deterioration. Write the condition below the product where it is found.

    a. Matured cheese --_____.

    b. Herring packs; Swiss cheese; ham --_____.

    c. Grape juice in storage --_____.

    d. Fish and shellfish packs --_____.

25. Which of the following deteriorative conditions is responsible for the darkening of freshly peeled fruit?

    a. Rancidity.

    b. Enzymatic degradation.

    c Surface slime.

    d. Nonenzymatic browning.

    e. Staling.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. Food deterioration. A series of continuous degradative changes occurring in a food item which may affect the products' wholesomeness, result in a reduction of its quality, and/or its serviceability. (para 1-2a)

2. Food spoilage. An arbitrary end-point of the deterioration process which denotes that a food item is unwholesome and therefore is no longer suitable for human consumption. (para 1-2e)

3. Abnormal. A sensory evaluation term that refers to those characteristics exhibited by a food item which is judged to differ from the normal characteristics. It does not lie within the permissible variations possessed by high-quality like items. (para 1-2f)

4. Quality. A term that refers to the degree of excellence or grade of a product. (para 1-2c)

5. Wholesomeness. A term that refers to freedom from pathogenic or otherwise harmful microorganisms. (para 1-2b)

6. Serviceability. A term that refers to the usefulness of a food item. (para 1-2d)

7. Adulteration. An act or process, either intentional or unintentional, of making a food impure. (para 1-2g)

8. Color.
   Odor.
   Texture.
   Taste (flavor). (para 1-3b)

9. Closed-package inspection. An inspection of the product's packaging and packing materials for evidence of a deterioration condition. (para 1-4a)

10. Open-package inspection. An evaluation of a food component for evidence of a deteriorative condition. (para 1-4b)

11. Microorganisms.
    Action of enzymes.
    Chemical reactions.
    Physical changes.
    Time.
    Insects and/or rodents. (para 1-5)

12. Chlorophyll, solanine. (para 1-9f(3))

13. Color--white to pale amber.
Texture--dry and shriveled.
Taste--tasteless, stale. (para 1-13a)

14. Holes and voids causing the light to be reflected differently. (para 1-13b(2))

15. Oxidative Rancidity--oxidation of unsaturated fats.
Hydrolytic Rancidity--splitting of fatty acids, sometimes in the presence of lipolytic enzymes.
Ketonic Rancidity--Growth of microorganisms. (para 1-14)

16. Growth of bacteria. (para 1-15b)

17. Bacterial growth.
Oxidized flavor.
Hydrolytic rancidity. (figure 1-1)

18. Rancidity.
Browning.
Lactose crystallization.
Mold growth. (figure 1-1)

19. Rancidity.
Protein denaturation.
Color change.
Freezer burn.
Toughening. (figure 1-1)

20. Browning.
Rancidity.
Loss of color.
Loss of texture.
Loss of nutrients. (figure 1-2)

21. Loss of flavor.
Loss of texture.
Loss of color.
Loss of nutrients. (figure 1-2)

22. c (para 1-25c)

23. a (para 1.25i)

24. a. Calcium lactate deposits.
    b. Tyrosine deposits.
    c. Tartrate (argol) crystals.
    d. Struvite crystals. (para 1-22)

25. b (para 1-17c)

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2	Deterioration of Meat and Meat Products.
TEXT ASSIGNMENT	Paragraphs 2-1 through 2-18.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

2-1. Given a description of a deteriorative change in meat and/or meat products, identify the condition and the cause of the change.

2-2. Given a description of a deteriorative change in meat and/or meat products, determine whether or not the presence of a health hazard exists.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

DETERIORATION OF MEAT AND MEAT PRODUCTS

Section I. DETERIORATIVE CONDITIONS IN MEAT AND MEAT PRODUCTS

2-1. INTRODUCTION

a. **Duty of 91R20.** As a 91R20 veterinary food inspection specialist, you must verify the presence of deteriorative conditions in meat and meat products. As appropriate, you will confirm the inspection findings which indicate the presence of deteriorative subsistence. Deteriorative conditions include abnormal color, off-odor, abnormal texture, off-flavor, foreign material, and others.

b. **Duty of 91R10.** The 91R10 veterinary food inspection specialist's findings do not identify the deteriorative condition. Rather, the 91R10 notes abnormalities of the inspected product which may or may not indicate the presence of a deteriorative condition.

2-2. MICROBIAL SPOILAGE

a. **Characteristics of Deterioration in Food.** The microbial deterioration of a food is usually manifested by alterations in the appearance, texture, color, odor, or flavor or by slime formation. Alterations in appearance include color changes, formation of pockets of gas or swelling, and microbial growth (especially molds). As some meat products deteriorate, they tend to become soft or mushy. Degradation of food results in the formation of compounds which have odors and flavors different from those of the fresh food.

b. **Microbial Spoilage.** Examine the product for abnormal color(s), odor(s), and texture(s) which may indicate microbial deterioration. Microbial spoilage may be caused by yeast, mold, and/or bacteria. The particular color, odor, or texture change will depend upon the type or species of microorganisms involved.

c. **Color Changes.** The following color changes may indicate microbial spoilage: red spots; blue, green, purple, and yellowish discoloration; green core (sausage); greenish-blue to brownish-black spots; abnormal pink, cream color, or white coloration.

d. **Particular Odors.** The following odors have been associated with microbial deterioration: tainted, gassy, sour, cold storage flavor, musty or earthy, putrid, and acid. Poultry products may also exhibit a dishrag odor, similar to the smell of a dirty dishrag, usually a strong, sour odor.

e. **Texture Changes.** The following texture changes are associated with microbial spoilage: surface slime, stickiness, whiskers (fuzzy growth), spongy texture, surface growth, swelling (of vacuum-packed meats), and cloudiness.

f. **Tasting the Product.** If microbial spoilage is suspected, DO NOT TASTE THE PRODUCT. The veterinary officer should be contacted for further examination of the product.

g. **Growth of Microorganisms.** Since fresh animal products are perishable, they are chilled and stored in ice or a refrigerator at 0º to 4ºC (32º to 39ºF). This means that psychrophilic organisms (organisms capable of growing at refrigeration temperatures) become dominant. Microorganisms are the primary cause of spoilage in meat and meat products. Spoilage of meat is due to the growth and metabolism of large numbers of microorganisms on the surface or the interior. Most spoilage is on the surface. The number of organisms that are present when spoilage is evident varies from 10^6 to 10^8 per cm^2 of meat surface. This variation apparently is due to the activity of the organisms present, as well as the criteria used by the investigators to determine spoilage.

h. **Spoilage Organisms.** The temperature of the meat is perhaps the most important factor that determines the predominant microflora and the resultant spoilage. At temperatures of 50ºC (122ºF) or higher, thermophilic bacteria can grow. Usually these bacteria cause spoilage of heat-processed meats that have been improperly handled during processing. Intermediate temperatures (15º to 30ºC) (59º to 86ºF) may occur when the chilling of meat is slow, delayed, or the meat is held in this temperature range. In these cases, the main spoilage organisms are the mesophilic clostridia. They cause internal spoilage or bone taint in beef. At low temperatures (0ºC, 32ºF), spoilage is evidenced on the surface. Under storage conditions which foster a moist meat surface, spoilage is due to gram-negative bacteria, especially Pseudomonas species.

i. **Water as a Factor.** The water activity of the product can play a role in microbial spoilage. Water activity (a_w) is defined as the ratio of the water vapor pressure of the food substance to the vapor pressure of pure water at the same temperature. This is an index of the availability of water for chemical reactions and microbial growth. At an a_w of 0.96 or less, most of the usual microorganisms causing spoilage of fresh meat are inhibited. When the surface of meat has an a_w lower than 0.96, the slower-growing fungi become evident. The conditions seen will be "whiskers" caused by Thamnidium, black spot caused by Cladosporium, and white spot caused by Sporotrichum. Generally, the activity of molds is limited to the outer surface of meat where aerobic conditions prevail.

j. **Odor and Slime.** The main conditions of microbial spoilage in poultry are off-odor (which appears at a bacterial load between 10^6 to 10^8 per cm^2) and slime formation (which occurs soon after off-odor is noted). Slime is the descriptive term which describes the massive accumulation of microbial cells on the product surface as the result of extensive growth. Species of Pseudomonas are the principal spoilage organisms of poultry. Some of the chemical compounds found on spoiled chicken included H_2S (hydrogen sulfide), acetone, methanol, and many other odoriferous compounds.

k. **Gas Formation.** The development of gas in cured meats is occasionally encountered, especially in the manufacture of fermented sausages. Lactic acid bacteria (lactobacilli and leuconostocs) and yeasts produce copious quantities of carbon dioxide from the fermentation of the added sugar. This gas produces large numbers of pinholes in sausage and a constant swelling of the product. Burst casings are often encountered. Gassiness in hams and frankfurters is also observed. Among frankfurters, the effects become dramatic when vacuum packages are used. The packages retain the gas as it diffuses from the product and may become inflated.

l. **Summary of Microbial Conditions.** The various microbial conditions seen in meat and meat products are summarized in figure 2-1.

PRODUCT	CONDITION(S)
Fresh red meats	Off-odor, Sliminess (stickiness), Discoloration, Moldiness, Whiskers, White spot, Black spot, Bone taint, Gassiness, Souring
Vacuum packaged (fresh)	Acidity, Sweetness, Rancidity
Bacon	Cheesy texture, Souring, Rancidity, Discoloration, Slime formation
Vacuum packaged (cured)	Cabbage odor Taint
Ham	Surface slime, Gassiness or puffiness, Green discoloration Bone and meat sours
Sausages	Slime on surface, Gas production, Greenish discoloration
Fermented sausage	Slime Spots (discoloration)
Canned meats	Gas, Putrefaction, Souring, Discoloration
Poultry	Off-odor Slime
Vinegar-pickled meats	Cloudy or ropy brine

Figure 2-1. Microbial conditions of meat and meat products.

2-3. OXIDATIVE RANCIDITY

a. **General.** Examine the product for abnormal color, flavor, and odor. A discussion of oxidative rancidity may be found in paragraph 1-14a.

b. **Definition.** Oxidative rancidity is caused by oxidation of unsaturated fats. The following are examples of meat and meat products with a high content of unsaturated fats: chicken, poultry, pork, and bacon.

c. **Color Changes.** Yellowing of the fat and/or browning of the meat are color changes that may indicate oxidative rancidity.

d. **Flavor Changes.** Flavor may vary and is dependent upon the stage of reaction. A sharp, biting, acrid (burning) flavor is indicative of an advanced stage of oxidative rancidity, sometimes called "rancid" flavor.

e. **Cooking a Sample for Evaluation.** A cook test may have to be performed to evaluate the flavor. The rancid flavors may not be evident at the low temperatures at which meat and meat products are stored.

2-4. DEHYDRATION

a. **General.** Examine the product for a dried or porous surface or a dark color. These may indicate dehydration.

b. **Definition.** Dehydration is a loss of water from the product, usually due to improper storage conditions.

c. **Appearance in a Nonfrozen Product.** Dehydration in a nonfrozen product results in a dried-out (dry, shrunken) appearance of the surface, usually accompanied by a darkening of the product. The darkening is due to an accumulation of solid matter.

d. **Appearance in a Frozen Product.** Dehydration (freezer burn) in a frozen product is evidenced by a porous texture, whereby the tissue becomes tough and fibrous. When this condition exists, protein denaturation normally occurs. The abnormal color may range from white to pale amber in affected areas and may appear as patch-like areas. The affected product will retain its original shape. A discussion of freezer burn may be found in paragraph 1-13.

2-5. DISCOLORATION/DARKENING

a. **General.** Examine the product for discoloration/darkening.

b. **Sources of Discoloration.** Discoloration/darkening may be due to hydrolysis reactions, surface evaporation, or microbial spoilage.

c. **Other Sources.** The inspector may find other deteriorative conditions such as dehydration or microbial spoilage in determining discoloration in meat and meat products.

d. **Surface Discolorations.** The following surface discolorations may be observed in meat and meat products.

(1) Browning. A brownish discoloration on the cut or outside surface of ham or sausage is often associated with dehydration. The cured meat pigment is chemically altered to metmyoglobin under storage conditions. Low humidity, especially at storage temperatures considered to be too high for the product, may result in a rather rapid browning of cured meat products. A packaging film which is less permeable to water and oxygen will retard the onset of this type of discoloration. Browning of the lean areas of bacon is commonly observed. In addition to dehydration, the discoloration is sometimes traced to the presence of excessive nitrite. A high nitrite content will tend to oxidize the pigment in the cut lean surfaces to metmyoglobin.

(2) Fading due to undercure. Fading may be an indication of insufficient nitrite in the cure. Consequently, a low residual nitrite level will result in a weak cured color. This type of discoloration is often observed on the cut surfaces of hams or in such products as frankfurters. Under such conditions, the interior color is pale pink, which tends to fade rapidly upon exposure to oxygen.

(3) Greening due to overcure. Nitrite burn, which is due to an excess of nitrite in the cure, is often observed in acid-cured meat products such as the fermented sausages and pickled pigs' feet. In fermented sausages, it may arise from excessive nitrite reduction by bacteria during the fermentation process. Nitrite burn in pickled pigs' feet usually produces a browning of the muscle tissues and an undesirable greening of the skin and other collagenous tissues. Even the vinegar pickle may acquire a greenish tint.

(4) Fading from rancid fats. Fats with a high organic peroxide content are sometimes incorporated into sausages. This may result in instability of the surface color. Such fats may also impair the flavor of the product. Attempts to store frankfurters for prolonged periods of time in the frozen state often result in rancidity development and surface fading.

(5) Chemical fading. Although the cured meat pigment is heat stable, it is very susceptible to oxidation. Any oxidizing chemical applied to the cured meat surface may result in a discoloration. For example, very dilute solutions of hydrogen peroxide will cause a fading or greening of the cured meat surface. Overzealous use of hypochlorites as sanitizing agents can result in difficulties if any of the chemical reaches the surface of cured meats.

(6) Bacterial greening. Surface discoloration of sausages and other cured meats caused by bacteria is common.

(a) The bacteria are deposited in the surfaces during the usual handling procedures following heat processing. If suitable environmental conditions are provided, these bacteria grow rapidly on the surface and discolor the cured meat pigment through hydrogen peroxide accumulation.

(b) Several kinds of bacteria are capable of producing a greenish discoloration of meat pigment. They include the following genera: Lactobacillus, Leuconostoc, and Pediococcus.

(c) Bacterial greening of meat surfaces is a direct reflection of malpractice in sanitation and/or holding conditions of the finished product. Contamination occurs usually as the result of direct contact with equipment, employees, or another product harboring the microorganisms.

(d) Following contamination, if the product is held in an environment that maintains a moist surface and a suitable growing temperature, the discoloration becomes apparent. Discoloration is usually accompanied by a slimy surface, caused by heavy bacterial growth.

e. **Interior Discolorations.** The following interior discolorations may be observed in meat and meat products.

(1) Overcure or undercure.

(a) An excess of nitrite, especially in the fermented sausages, may result in a greenish core, which is apparent at the time of cutting the sausage. Green cores may also accompany surface greening from nitrite burn.

(b) Conversely, insufficient nitrite may result in a faded interior of a cured meat. This condition is seen in hams and sometimes results from a rupture of the vascular system at the time of pumping the ham with curing pickle. In this event, there may be a portion of the ham which never receives a sufficient quantity of the curing agents.

(2) Green rings and cores.

(a) Green rings in sausages are known to be of bacterial origin, although the exact mechanism of their formation is unknown. The rings appear at varying depths beneath the surface, usually 2 to 4 mm, and may be of varying thicknesses. They are apparent at the time of cutting and tend to fade within a few hours.

(b) Green cores of bacterial origin occur rather commonly, especially among the larger sausages. The discolored core is not apparent at the time of cutting but becomes visible within one to several hours after exposure to the air. In several cases, the discoloration may show through to the surface. A common microorganism associated with sausage green cores is Lactobacillus viridescens. This bacterium has an extreme thermal tolerance (very heat-resistant).

(c) Another similar internal greening problem occasionally encountered is the discoloration of canned hams. At the time of opening, the tissues appear normal. However, when they are sliced and packaged for display purposes, the color may fade or turn green rapidly. Streptococcus faecium is often found to be the responsible microorganism in such instances. This bacterium is relatively heat-resistant and is able to grow at refrigeration temperatures. This organism survives the thermal processing during canning of the ham and grows rapidly prior to the time of opening. There is no swelling of the can and it may have no off-flavors or off-odors, with the exception of an occasional sour flavor.

f. **Normal Fresh Red Meat Colors.**

(1) When fresh red meat is initially cut, the myoglobin (muscle pigment) color is a purplish red. See figure 2-2 for color changes.

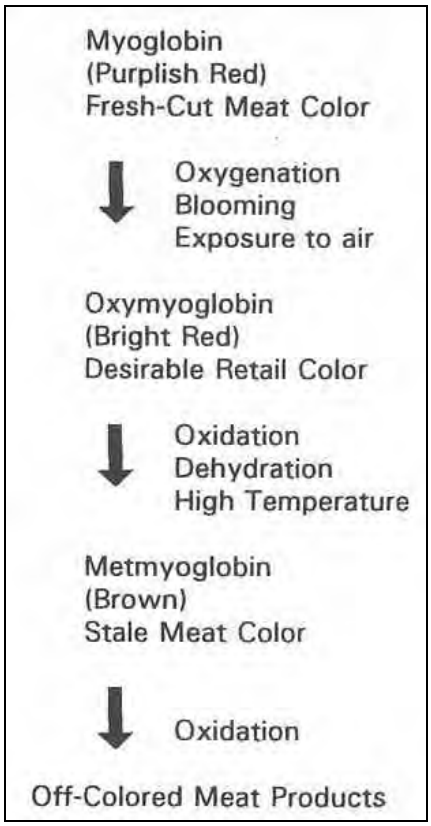


Figure 2-2. Fresh red meat color changes.

(2) On exposure to air, an oxygen molecule is added directly to the iron portion (oxygenation) of the myoglobin. This yields oxymyoglobin, which has a bright red color. This step is often called "blooming." This is the reason oxygen-permeable wrapping material is used with fresh meat. (Vacuum-packaged meat has a dark color when opened due to the blocking of this reaction (oxygenation).

(3) Upon exposure to oxygen, further oxidation takes place, and the iron in the oxymyoglobin is changed from a valence of +2 to a valence of +3 and this yields metmyoglobin, which is a brown pigment. Dehydration and high temperatures accelerate this reaction.

(4) Further oxidation of metmyoglobin yields off-colored meat, which is often green.

g. **Normal Cured Red Meat Color.** Cured red meat color depends on the reaction of nitric oxide (NO) with myoglobin to produce nitrosomyoglobin, which is a pinkish red pigment. To obtain NO, sodium or potassium nitrate/nitrite is added to the curing mixture. The nitrate is reduced to nitrite by bacterial reaction. The nitrite is converted to nitrous acid and finally to NO, which is a gas. Low pH, ascorbic acid, and other reducing conditions accelerate these reactions. The NO then reacts with myoglobin to produce nitrosomyoglobin. Nitrosomyoglobin may be oxidized to the undesirable brown pigment metmyoglobin. To block this reaction, cured meat is wrapped in oxygen-impermeable paper. Normally, after curing, heat is applied to the product during smoking. At this time, nitrosomyoglobin is converted to nitrosohemochrome. The globin portion of the pigment is fragmented and the cured meat takes on a bright purplish red color. See figure 2-3.

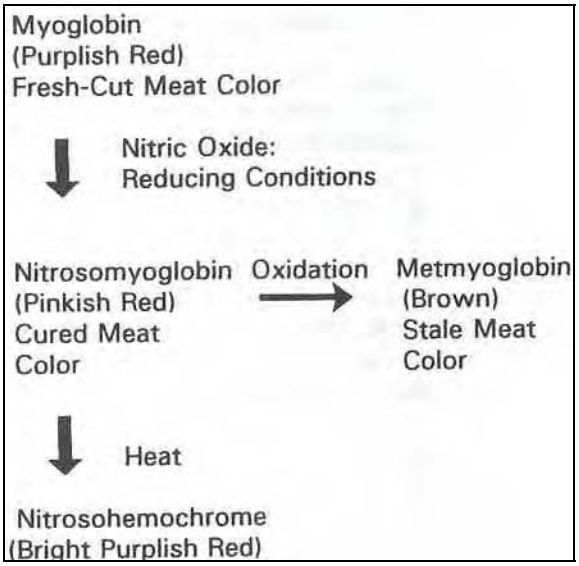


Figure 2-3. Cured red meat color changes.

2-6. FOREIGN MATERIAL

a. **General.** Examine the product for the presence of foreign material. Foreign material is any extraneous matter which does not organically belong where found, which has been introduced from the outside, or which does not naturally occur in the quantity found at the location examined. The possibilities for foreign material in meat and meat products include the following.

b. **Ammonia Contamination.** This contamination usually is associated with leakage accidents in cold storage facilities. The odor of ammonia is readily absorbed into the fatty tissue of a meat product. Trimming of the product may be acceptable in many cases. If the odor has been absorbed by the lean tissue, elimination of the odor is virtually impossible. Condemnation is then necessary. Packing and packaging offer some protection for meat items, but little research has been conducted to verify the degree of protection offered. Determination of acceptability of the product is best determined by allowing samples of the product to warm up to normal room temperatures.

c. **Mechanical Contamination.** Care is constantly exercised to avoid the contamination of meat and its products with metallic particles and similar foreign material. Otherwise, these materials adhere or drop into the meat as it progresses through the meat-packing plant. Contamination may be due to one of the following situations.

(1) The edges of shovels used in the handling of chopped and ground meat may wear thin, roll, and crumble into the meat product.

(2) Staples from metal-stitching machines are a source of contamination.

(3) Metal and plastic tag fasteners and wood and metal skewers used in the identification of carcasses in the slaughtering department are a source of contamination.

(4) Welds are another possible source of metal particles in meat.

(5) Glass is a source of foreign material in meat. Light bulbs are normally protected when suspended directly over choppers, grinders, mixers, or other exposed product.

(6) Flaking paint and rust are also constant problems in meat-processing plants.

(7) Grease or oil used to lubricate trolleys, conveyor chains, and gear boxes is also a source of contamination.

2-7. PARASITES

a. **General.** Examine the product to detect any parasites present in the product and classify them as being parasites. A parasite is any organism that grows on or in another organism in such a way to damage or harm the other organism.

b. **Beef Measles (Cysticercus bovis).** This parasite, commonly called C. bovis or beef measles, often occurs in cattle. It is the infective stage of a tapeworm of man, Taenia saginata. Man acquires the tapeworm by eating improperly cooked infective beef. When the beef animal consumes the infective stage, the larvae migrate to specific tissues and form a cyst. It is the cyst that we are trying to locate in the product. The cyst is found chiefly in jaw muscles, heart, diaphragm, and any red muscle of the beef carcass. Hopefully, the cyst will be found on postmortem examination of the beef carcass. Carcasses of cattle displaying lesions of C. bovis should be condemned if the infestation is extensive. If the infestation is not extensive, the carcass is passed for food after removal of the cysts and after the carcass is held continuously at a temperature not higher than 15ºF (-10ºC) for a period of not less than ten days.

c. **Pork Measles (Cysticercus cellulosae).** This disease is known as pork measles. The cystic form of Taenia solium, pork tapeworm of man, produces the bladder worm, C. cellulosae, in its intermediate host, the swine. The cysts are found in subcutaneous tissues, striated muscles, and other tissues of the pork carcass. Affected muscles may resemble grapelike clusters of cysts. A carcass affected with pork measles is unfit for food.

d. **Liver Flukes.** Fasciola hepatica and Fascioloides magna are two different types of liver flukes that may infest the livers of cattle and sheep. The liver flukes live in the bile ducts of the liver, but they may migrate to other tissues of the carcass. The diaphragm, lungs, and skeletal muscles are occasionally affected, and the lesions contain a characteristic black pigment. The infested liver has uneven surfaces due to great damage and encapsulation of the parasite in the organ. There is also characteristic black pigmentation of the liver and lymph nodes of the region. Affected livers are unfit for food, regardless of the extent of the infestation. The other affected parts of the carcass must be trimmed and removed. Trimming is done to remove any scar tissue and pigmentation due to migration of the flukes.

e. **Other Parasites.** There are several other parasites of importance to man. However, they can normally be detected in meats only by the use of a microscope.

(1) Sarcocystis. This involves parasitic protozoa. The ingested spore-containing cyst reaches the small intestine, the spores are freed, and they multiply and migrate to muscular tissue, where they grow and develop into sarcocysts. No human deaths caused by this parasite have been reported.

(2) Trichinosis. The causative agent of this disease is Trichinella spiralis. The host acquires the infection by eating viable encysted larvae in the muscles of infected animals. Man becomes infected by eating the larvae in raw or partially cooked pork products. Swine are infected by eating raw or partially cooked garbage that contains uncooked meat scraps. Many may also be infected by eating beef products (such as hamburger) that have been adulterated either intentionally or inadvertently with pork. The clinical disease in man is highly variable, ranging from a mild febrile disease to a fulminating fatal disease. The diagnosis of Trichinella spiralis infection in pork depends principally upon detection of the encysted larvae by an inspecting veterinarian.

(3) Hydatidosis. This disease in humans is caused by the larval stage or hydatid cyst of two species of tapeworms, Echinococcus granulosis and E. multilocularis. Dogs, the natural hosts of the adult form, become infected by eating the meat of animals containing the cysts. Humans contact the disease when dogs have access to uncooked viscera of meat animals and pass the infective eggs on to the carcass of the meat animals.

2-8. DETERIORATION OF UNKNOWN CAUSE

Examine the product for deteriorative changes. Once the changes have been identified but a cause is not known, you should notify the veterinary officer. The veterinarian will determine the cause. If the cause of the deterioration cannot be determined, then the veterinary officer will have you prepare a sample for submission to the medical laboratory. For additional information, see subcourse MD0694, Basic Food Inspection Procedures.

2-9. DETERMINING THE AMOUNT, SEVERITY, AND EXTENT OF A DETERIORATIVE CONDITION

Following the determination of the deteriorative condition in the meat product, determine the amount of deteriorative condition present in the product. You, the 91R20 veterinary food inspection specialist, will determine the severity and extent of the product deteriorative condition. For this, you will use contractual documents or local SOP, as applicable. This information may have already been supplied by the 91R10 veterinary food inspection specialist's inspection reports.

Section II. DETERMINATION OF POTENTIAL HEALTH HAZARDS, RECOMMENDATIONS, AND REFERENCES

2-10. INTRODUCTION

Determine the existence of any potential health hazard, based upon the deteriorative condition and the amount of product deterioration. A health hazard is defined as any substance that could harm a person's health and/or well-being.

2-11. DEHYDRATION

Dehydration does not present a potential health hazard; however, in severe cases, it may increase oxidative rancidity, which may be a health hazard.

2-12. OXIDATIVE RANCIDITY

If this deteriorative condition is present in severe quantities, a potential health hazard does exist. High levels of malonaldehyde are found in rancid foods. Malonaldehyde is a decomposition product of polyunsaturated fatty acids. This chemical has been reported to be carcinogenic (causing cancer). Thus, a potential health hazard does exist. However, foods with sufficient malonaldehyde to cause problems will have such an off-odor and off-flavor that a person would not normally consume that product.

2-13. FOREIGN MATERIAL

Foreign material must exceed certain formal guidelines to present a health hazard. The type of foreign material found on the product will also determine the health hazard potential.

2-14. PARASITES

Generally, parasites do not constitute a potential health hazard. Identity of the parasitic condition must be confirmed by the veterinary officer to determine if a health hazard exists.

2-15. MICROBIAL PATHOGENS

Depending upon the microorganisms present in the product, microbial spoilage certainly may be a potential health hazard. The microorganisms listed below are a potential health hazard in meats and meat products:

a. **Salmonella Species**. Salmonellosis is a food-borne illness caused by any one of the more than 1200 species of Salmonella. Fairly large numbers of about one million living bacteria must be consumed to be an infective dose for a young and healthy person. The US Food and Drug Administration considers 15 to 20 Salmonella cells as potentially infective for humans. (It depends upon the age and health of the host and strain differences among the members of the genus.) The greatest sources of potential danger are fresh meats and meat products that have become recontaminated after processing. Ground beef and fresh pork sausage are frequently contaminated by this procedure. Note that proper cooking will kill the majority of all Salmonella species.

b. **Clostridium perfringens.** This food poisoning organism is a normal inhabitant of the intestinal tract of man and animals and may be found in soils, dust, water, and foods. The majority of food-borne illnesses caused by Cl. perfringens occurs

in institutions (such as hotels, school cafeterias, and university dining rooms) and at dinners and picnics where large numbers are in attendance. The foods involved are almost always meat and poultry products which have been cooked and left unrefrigerated at warm temperatures for several hours. The food appears normal in appearance, taste, and smell, but very large numbers of organisms may be present.

c. **Clostridium botulinum.** The most serious but fortunately the rarest type of food poisoning is botulism. Botulism is caused by the extremely potent neurotoxin produced by the growth of Clostridium botulinum. The organism is widely distributed through the soil and may be only rarely present in meat products. There is a low reported incidence of all clostridial spores in meats. Most of the foods involved in the US have been improperly home-canned vegetables. However, a 1963 outbreak, arising from improper commercial processing of liver paste, illustrates the possibility of this type of food poisoning taking place in meat products.

d. **Staphylococcus aureus.** There is a toxicogenic type of food poisoning caused by the growth of S. aureus. The staphylococcal enterotoxin responsible for the food poisoning is very resistant to heat and is much more heat resistant than the organism. This organism is widely distributed in nature. It has been isolated from the noses of approximately 50 percent of normally healthy individuals. It frequently infects cuts, burns, abrasions, and hair follicles. Thus, any meat product that is touched by human hands stands a reasonable chance of being inoculated with staphylococci. The foods most commonly involved in this foodborne illness are poultry products and ham.

e. **Escherichia coli 0157:H7.** There is a toxicogenic type of diarrhea caused by E. coli 0157:H7. It is sometimes called "hemorrhagic colitis" and is a more severe form of diarrhea than the more common "traveler's disease." The diarrhea is initially watery but becomes bloody. It can lead to life-threatening conditions for the very young and, in the elderly, to a condition with a 50 percent mortality rate. The food most commonly involved in this illness is undercooked or raw ground meat.

f. **Other Microorganisms.** Occasionally, there have been other bacteria implicated in food poisoning outbreaks besides the four types just discussed. These include Streptococcus faecalis, Bacillus cereus, Proteus species, Escherichia coli, and Brucella species.

2-16. DETERMINATION

In the case of deterioration of unknown cause, the veterinarian will need to make the decision as to whether a potential health hazard is present or not.

2-17. RECOMMENDATIONS

a. **Inspector Action.** Utilizing all known information regarding the deteriorative meat and meat products, you will make recommendations concerning the product. Complete the appropriate forms and reports in accordance with local SOP.

b. **A Potential Health Hazard.** If you determine that a potential health hazard exists or is suspected to exist, you must notify the veterinary officer.

c. **Destination Inspection.** If you find no potential health hazard in a destination/ procurement inspection, you must determine the compliance of the product based upon comparison of known information with information taken from the inspection data packet or local SOP.

d. **Surveillance Inspection.** If you find no health hazard in a surveillance inspection, you must determine serviceability after comparing known information with standards established by DLA 4155.37, Appendix S; DPSC Manual 4155.7; AR 40-656; or local SOP as applicable. You must consider the following factors:

(1) Suitability for intended use.

(2) Expected usage date.

(3) Amount of product in storage.

(4) Storage environment.

e. **Disposition of the Sample.** Following the determination of recommendations, you must determine the disposition of the sample. See subcourse MD0704, Inspection Records and Reports, for further information.

2-18. REFERENCES

The following references may be used in the determination of deteriorative conditions of meat and meat products:

a. DLA 4155.37 Appendix S, Quality Control Depot Serviceability Standards.

b. DPSC Manual 4155.7, Subsistence In-Storage Quality Control and Inspection.

c. AR 40-656, Veterinary Surveillance Inspection of Semiperishable Foods.

d. AR 40-657, Veterinary Food Inspection.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or by writing the answer in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the exercises and check your answers. For each incorrect answer, reread the material referenced after the answer.

1. Under storage conditions which foster a moist meat surface, spoilage is due to gram-negative bacteria, especially _____ species.

2. The water activity of a product is an index of the availability of water for _____ _____ and _____ _____.

3. The main conditions of microbial spoilage in poultry are _____ and _____.

4. Slime is a descriptive term which describes the _____ _____ of microbial cells on the _____ _____ as the result of extensive growth.

5. The development of gas in cured meats is usually due to _____ _____ bacteria and _____.

6. A _____ test may have to be performed to evaluate the flavor of meat and meat products since rancid flavors may not be evident at the low temperatures at which meat and meat products are stored.

7. A brownish discoloration on the cut or outside surface of ham or sausage is often associated with _____.

8. Fading of cured meats may be due to insufficient _____ in the cure or exposure to _____.

9. Greening of acid-cured meat products is due to _____ _____, which is due to an excess of nitrite in the cure.

10. Dilute solutions of hydrogen peroxide will cause a _____ or _____ of a cured meat surface.

11. Bacterial greening of sausages is due to the following genera of microorganisms:

    a. _____.

    b. _____.

    c. _____.

12. Green cores of bacterial origin are seen rather commonly in larger sausages. A common microorganism associated with green cores in sausages is _____ _____.

13. Oxymyoglobin is due to the _____ of myoglobin.

14. List the normal colors of the following fresh meat pigments:

    a. Myoglobin --_____.

    b. Oxymyoglobin --_____.

    c. Metmyoglobin --_____.

15. Label each of the compounds below with its color. Such colors may be seen in cured red meat.

    a. Myoglobin _____ _____.

    b. Nitrosomyoglobin _____ _____.

    c. Metmyoglobin _____.

    d. Nitrosohemochrome _____ _____ _____.

16. The odor of ammonia is readily absorbed into the _____ _____ of a meat product.

17. Carcasses of cattle displaying lesions of Cysticercus bovis should be _____ if the infestation is extensive.

18. Pork measles is due to the cystic form of _____ _____, which is the pork tapeworm of man.

19. Man becomes infected with trichinosis by eating the larval stage of _____ _____ in _____or _____pork products.

20. Oxidative rancidity in meat and meat products considered a potential health hazard because of the formation of _____which has been reported to be _____.

21. The foods involved in Clostridium perfringens foodborne illness outbreaks are most commonly meat and meat products which have been _____ and left at warm temperatures for _____.

22. The disease hydatidosis in humans comes from infected meat and is caused by the cyst of the parasite:

    a. Taenia solium.

    b. Echinococcus granulosis.

    c. Taenia saginata.

    d. Fascioloides magna.

23. White spots in meat or meat products are caused by:

    a. Thamnidium.

    b. Cladosporium.

    c. Sporotrichum.

    d. Leuconostoc.

24. The principal spoilage organisms of poultry are species of:

    a. Salmonella.

    b. Streptococcus.

    c. Lactobacillus

    d. Brucella.

    e. Pseudomonas.

25. In which of the following is the inspector more likely to find cabbage odor?

    a. Sausages.

    b. Vacuum packaged meat (fresh)

    c. Fresh red meats.

    d. Vacuum packaged meat (cured).

    e. Ham or bacon.

26. In which of the following is the inspector more likely to find gassiness and bone and meat sours?

    a. Ham.

    b. Bacon.

    c. Poultry.

    d. Sausages.

    e. Fresh red meats.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. Pseudomonas. (para 2-2h)

2. chemical reactions; microbial growth (para 2-2i)

3. off-odor; slime formation (para 2-2j)

4. massive accumulation; product surface (para 2-2j)

5. lactic acid; yeasts (para 2-2k)

6. cook (para 2-3e)

7. dehydration (para 2-5d(1))

8. nitrite; oxygen. (para 2-5d(2))

9. nitrite burn (para 2-5d(3))

10. fading; greening. (para 2-5d(5))

11. Lactobacillus.
    Leuconostoc.
    Pediococcus. (para 2-5d(6)(b))

12. Lactobacillus viridescens. (para 2-5e(2)(b))

13. oxygenation (para 2-5f(2))

14. a. Purplish red.
    b. Bright red.
    c. Brown. (figure 2-2)

15. a. Purplish red.
    b. Pinkish red.
    c. Brown.
    d. Bright purplish red. (figure 2-3)

16. fatty tissue (para 2-6b)

17. condemned (para 2-7b)

18. Taenia solium. (para 2-7c)

19. Trichinella spiralis; raw; partially cooked (para 2-7e(2))

20. malonaldehyde; carcinogenic (para 2-12)

21. cooked; unrefrigerated; several hours (para 2-15b)

22. b (para 2-7e(3))

23. c (para 2-2i)

24. e (para 2-2j)

25. d (figure 2-1)

26. a (figure 2-1)

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3	Deterioration of Waterfoods.
TEXT ASSIGNMENT	Paragraphs 3-1 through 3-22.
LESSON OBJECTIVES	After completing this lesson, you should be able to:
	3-1. Given a description of a deteriorative change in waterfoods, identify the condition and the cause of the change.
	3-2. Given a description of a deteriorative change in waterfoods, determine whether or not the presence of a health hazard exists.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

DETERIORATION OF WATERFOODS

Section I. DETERIORATIVE CONDITIONS IN WATERFOODS

3-1. INTRODUCTION

a. **Duty of 91R20.** As a 91R20 veterinary food inspection specialist, you must verify the presence of deteriorative conditions in waterfoods. As appropriate, you will confirm inspection findings indicating the presence of deteriorative subsistence. Deteriorative conditions include abnormal color, off-odor, abnormal texture, off-flavor, foreign material, and others.

b. **Duty of 91R10.** The 91R10 veterinary food inspection specialist's findings do not identify the deteriorative condition. Rather the 91R10 notes abnormalities of the inspected product which may or may not indicate the presence of a deteriorative condition.

3-2. MICROBIAL SPOILAGE

a. **Relatively Rapid Deterioration.** From the moment fish are taken from the water, a series of deteriorative changes start to occur which eventually will render the fish unmarketable. Since these changes occur relatively rapidly, fish are probably the most perishable of all flesh foods. Microbiological action produces the most extensive of the deteriorative changes.

b. **Product Examination by the Inspector.** Examine the product and note abnormal color(s), odor(s), and/or texture(s) typical of microbial deterioration. Microbial spoilage may be caused by bacteria, mold, and/or yeasts. The particular color, odor, or texture change(s) involved will depend upon the type or species of microorganism involved.

c. **Caution to the Inspector and Appropriate Action.** If microbial spoilage is suspected, <u>THE INSPECTOR SHOULD NOT TASTE THE PRODUCT</u>. He should contact the veterinary officer for further examination of the product.

d. **Color Changes.** The following color changes may indicate microbial spoilage: red, pink, chocolate brown, yellowish green, black, brown, and so forth

e. **Odor Changes.** The following odor changes have been associated with microbial deterioration: muddy, musty, sour, putrid, soapy, milky, fecal, brine-like, sweet, yeasty, ammonia, hydrogen sulfide, fruity, dishraggy, wet hair, wet dog, and so forth.

f. **Changes in Texture.** The following textural changes may be associated with microbial deterioration: slimy, foamy, bubbly, soft, honeycombed, turbid, and jellylike.

g. **Flavor Changes.** Even though you, the 91R20, will **NOT** taste the product, you should be aware that the following flavor changes have been associated with microbial deterioration: muddy, musty, feedy (like animal feed).

h. **Common Spoilage Organisms.** The most common type of spoilage organisms in fish are gram-negative psychrophilic bacteria. The chief genera of this group are Pseudomonas and Achromobacter. These organisms cause slime formation, discoloration, and putrefaction of the product.

i. **Honeycombing.** A condition called honeycombing is found in canned tuna and salmon. It is caused by gas-forming bacteria present prior to canning. This is indicative of decomposed fish being utilized in the canning process. It is evidenced by small pitted holes in the surface flesh, which may extend through two or more layers. It can also be detected as a sharp taste during a sensory evaluation.

j. **Pink or Red Oysters.** A pink- or red-colored oyster indicates a deteriorative condition due to the growth of yeast at 0ºF (-17.8ºC) and below. The change in color starts as pinpoint specks. When the oyster is thawed, both the meat of the oyster and the liquid will become uniformly red. This can also be caused by the oysters eating small microscopic animals called dinoflagellates. Red pigments accumulate in the liver and give the oyster a pink or red color.

k. **Green-Gilled Oysters.** Green-gilled oysters represent another condition that may be observed. This condition is caused by the accumulation of a pigment in the gills and mantle. The bluish or greenish pigment is derived from certain types of diatoms. Diatoms are a family of minute algae upon which the oysters feed. The pigments are temporarily stored in the blood cells. These blood cells fill up the blood vessels of the gills and mantle. The color will be more evident in the gills than in any other area of the body.

l. **Cotton or Milky Shrimp.** A condition known as cotton or milky shrimp may be observed during the inspection of shrimp. It is due to parasitic protozoa (Microspordia). The flesh of the shrimp becomes soft and gelatinous and reminds one of a puffed-up piece of cotton or cottage cheese curds.

m. **Fish Steaks and Fillets.** Filleted and steaked fish are particularly susceptible to the deleterious effects of bad handling. This is because the naked fish provides an excellent medium for bacterial growth. Theoretically, a fillet carefully prepared from a fresh fish should be nearly sterile; all bacteria are initially present only on the exterior surfaces of the fish. However, filleting knives, tables and boards, filleter's gloves, wash water, and so forth, rapidly accumulate large populations of bacteria if proper sanitary precautions are not observed. A summary of the condition characteristics of fresh, stale, and putrid fish may be found in figure 3-1. Those characteristics that apply to fillets and steaks are marked with an asterisk.

	FRESH	STALE	PUTRID
APPEARANCE*	Bright bloom	Dull	Dull - dry
ODOR*	Devoid of odor or odor is characteristic of species	Slight off-odor (fishy odor, trimethylamine)	Offensive odor (ammonia)
EYES	Bright, prominent, clear	Opaque, dull, sunken, red bordered	Greatly sunken, broken down, devoid of definition or color
GILLS	Red, free of odor	Reddish-gray, pale yellow, slight odor	Dark brown, offensive odor
SCALES	Glisten, firmly adherent	Dull, loose, easily removed	Dry, loose, come off in hand
SURFACE SLIME	Clear, odorless, or creamy white	Devoid of color or dark, viscous, slight odor	Dry and very sticky, offensive odor
FLESH*	Firm, elastic, tight on bones, finger impressions do not remain	Soft, flabby, finger impressions remain	Withered, flabby, finger impressions remain
BLOOD*	Bright red, no odor	Dark brown, slight odor	Dirty brown, offensive odor

* Applies to fillets and steaks.

Figure 3-1. Condition classification: characteristics of fresh, stale, and putrid fish.

n. **Surveillance Inspection.** Microbial spoilage may develop in conjunction with other deteriorative or unacceptable conditions. If found during a surveillance inspection, all conditions should be reported to the accountable officer.

o. **Summary of Microbial Spoilage.** A summary of the microbial conditions of waterfood and spoilage organisms is found in figure 3-2.

PRODUCT	CONDITION	MICROORGANISM
FRESH FISH	Off-odor Fruity H_2S odor	Pseudomonas, Vibrio, Proteus Pseudomonas Pseudomonas
SALTED FISH	Pink Red growth Cheesy	Halobacterium Sporendonema Halophilic bacteria
OYSTERS	Pink Red	Yeasts Serratia marcescens
SHRIMP	Off-odor	Pseudomonas

Figure 3-2. Microbial conditions of waterfoods.

3-3. DEHYDRATION

a. **Definition.** Dehydration is a loss of water from a product, usually due to improper storage conditions. You, the veterinary food inspection specialist, will examine the product and determine if a dried or porous surface and a dark color exists. These are determining factors for this deteriorative condition.

b. **Non-Frozen Product.** Dehydration of a non-frozen product results in a drying out (dry, shrunken appearance) of the surface, usually accompanied by a darkening of the product. This darkening is due to an accumulation of solid matter.

c. **Frozen Product.** Dehydration (freezer burn) in a frozen product is evidenced by a porous texture, whereby the tissue becomes tough and fibrous. When this condition exists, protein denaturation normally occurs. The abnormal color may appear as patch-like areas. The affected product will retain its original shape.

3-4. WATERMARKING

Watermarking is a physiological change particular to salmon. Two changes may occur. One is a skin color change (light pink-brown to dark red-brown, depending on species) coupled with a thickening of the skin. The other change is mottling and color fading of the flesh. Watermarking that affects skin but does not noticeably affect the flesh is acceptable. If the flesh is noticeably affected, the product is not acceptable.

3-5. FOREIGN MATERIAL

Examine the product for the presence of foreign material. Foreign material is any extraneous matter which does not organically belong where found, which has been introduced from the outside, or which does not naturally occur in the quantity found at the location examined. This can include body parts (from rodents, insects, and/or birds), excreta, chemical compounds (paint, kerosene, or oil), sawdust, glass, and wood.

3-6. OXIDATIVE RANCIDITY

a. **Inspector Action.** You, the 91R20, will examine the product for abnormal odor, abnormal flavor, and abnormal color.

b. **Cause of Condition.** This condition is caused by oxidation of unsaturated fats. Fish products with 6 percent fat or less will normally not be affected by oxidative rancidity.

c. **Rusting (Color Change).** Rusting will also indicate oxidative rancidity. Rusting will cause a light yellow to brown discoloration.

d. **Characteristics of an Advanced Stage (Flavor/Odor Change).** A sharp, biting, acrid (burning) flavor and odor indicates an advanced stage of oxidative rancidity. Odor and flavor vary with the stage of the reaction. A complete discussion of oxidative rancidity may be found in paragraph 1-14a.

3-7. STORAGE BREAKDOWN

a. **Characteristics.** The inspector should note a slight loss of normal color accompanied by a slightly old odor or storage odor.

b. **Use of Cook Test.** The development of this condition is normal and results from a long storage period under ideal conditions or a short period under less than ideal storage. A cook test will determine the extent of this condition. A cooked product with storage breakdown will lack the color, texture, odor, and flavor characteristics of a fresh product.

c. **Inspector Action.** If you find extensive storage breakdown, the accountable officer should be notified.

3-8. PARASITES

a. **Definition.** A parasite is any organism that grows on or in another organism in such a way as to damage or harm the other organism. These may include internal and external worms.

b. **Inspector Action.** You should detect organism(s) present in the product and determine whether or not parasites are present.

c. **Detection Methods.** Candling the fish by incandescent lights is often used to detect parasites in fish. The parasites show up as dark areas or spots, not to be confused with blood spots or bruises. Other methods to detect parasites include ultraviolet (UV) light, high salt concentrations, and freezing out. The latter two methods force the parasites to the surface of the fish.

d. **Disease-Causing Parasites of Fish.**

(1) European or broad tapeworm. The fish tapeworm, called broad or European tapeworm (Diphyllobothrium latum) is identified by its segmented body and broad head. The tapeworm is found in cyst form in fish flesh. It is mostly found in the US in pike and pickerel fish midwestern or Canadian lakes. It is also found in some European freshwater fish. In man, it may grow to its adult size of 20 to 30 feet (within the intestinal tract). Infection (called diphyllobothriasis) is the result of eating raw or inadequately cooked fish. Proper preparation will render the cyst harmless. If it is cooked 10 minutes at 122ºF (50ºC) or frozen at 14ºF (-10ºC) for 24 hours, the parasite will be destroyed.

(2) Roundworm larvae. The roundworm larvae of the Anisakidae family are found in squid and saltwater fish from many parts of the world. Infected fish are common in US markets and may cause acute gastrointestinal distress (anisakiasis). This is caused by the ingestion of larval nematodes of the Anisakidae in raw or improperly prepared (salted, freezing, cooking, smoking) saltwater fish and squid. Heating at 140ºF (normal cooking temperature) or freezing at 4ºF for more than 60 hours kills the larvae.

e. **Commercially-Important Parasites of Fish.**

(1) Copepod (sea lice). The copepod (Sphyrion lumpi) is a small crustacean commonly found in Atlantic Ocean perch (Sebastes marinus). Like other crustaceans, it has a claw-like appendage which attaches to the flesh, causing areas of inflammation and abscesses. As a result, these parasites are usually visible to the naked eye. Trimming of the affected area is necessary to improve appearance; however, the flesh may be consumed without harm.

(2) Flatworm. The flatworm (Prosorphynchus, a trematode of the Bucephalus genus) is common to Pacific Ocean perch (Sebastodes alutus). This parasite passes from fish to shellfish and back to the fish to complete its life cycle. It encysts in the flesh, causing yellowish brown to black spots 1/8 inch to 1/4 inch in length. They are not normally visible to the naked eye. These flatworms are harmless to humans, but are removed for commercial purposes.

(3) Codworm. A worm which has caused major specification revision is the codworm (Porracaecum decipiens) which is common to the cod family but also may be found in haddock, pollock, and lake and ocean perch. It is also found in Pacific Ocean species. The codworm is the larval form of the roundworm of the seal, which must eat the fish for the worm to complete its life cycle. The infestation rate is very high for those fish caught inshore. If the fish are immediately processed and quick-frozen, the worm will normally be coiled to a diameter of less than 1/4 inch. In conventional frozen fish, worms tend to migrate towards the surface and can be detected by their light brown color in 1 1/2-inch lengths. Codworms are not harmful to humans, but they are removed because they affect the quality of fish flesh presented to consumers.

3-9. DETERIORATIVE CONDITIONS OF OYSTERS

a. **Spawny Oysters.** Spawny oysters can be identified by the presence of a translucent, milky-colored material. When moderate pressure is applied to the body of a shucked oyster, this fluid is released from within the oyster. This condition develops when the water approaches 50º to 70º F during late spring and early fall. On the Pacific Coast, there is a tendency for spawning to continue throughout the summer months. Since 2 to 5 percent of Pacific Coast oysters are spawny by this definition, a tolerance of one spawny oyster per pint has been established for each shipment of oysters.

b. **Oysters with Undernourished, Elongated Gills.** Undernourished, elongated gills are a condition that may develop in oysters after the heavy spawning periods. The condition normally occurs in late spring or early fall. The gills become thin, watery, and brownish in color. The body is thin and somewhat brownish, not whitish, the color that would indicate a fat oyster of high quality. There are many other factors that may produce this condition, for example, salinity of the water, lack of food, and turbidity of the water.

c. **Gaper.** A gaper is a dead oyster. The valves are parted and will not close when the oyster is disturbed. A gaper should not be included in a production lot. Since the time of death is not known and the degree of deterioration is also unknown, contamination to the balance of the lot could result.

d. **Measuring the pH Level.** Measuring the acid value of oyster liquor is a fairly accurate quality indicator since glycogen is converted to acid at a standard rate. At origin, fresh oysters must have a 6.2 pH level. At destination, the pH can drop to 6.0. When performing a surveillance inspection, a pH reading of 5.9 or 5.8 would indicate immediate issue. A pH below 5.8 is considered sour.

3-10. DETERIORATIVE CONDITIONS OF SCALLOPS AND SHRIMP

a. **Dark Gray or Black Scallops.** Dark gray or black scallop is a condition that develops when the scallops are not iced immediately after being caught. (Scallops are normally shucked at sea with only the adductor muscle being retained, packed in cloth bags, and then thoroughly iced.) The condition starts as a light grayish discoloration on the outside surfaces, becoming darker and penetrating inward. Light gray scallops may be accepted by the inspector.

b. **Diseased Scallops.** In diseased scallops, small pink nodules, approximately one-fourth inch in diameter, develop within the adductor muscle. The nodules contain a pus-like fluid. The condition is not necessarily confined to the surface. The cause of this condition is unknown. Any lot of scallops with evidence of this disease is rejected.

c. **Black Spot in Shrimp.** Black spot or "tigering" is a condition caused in shrimp by enzyme reactions in the presence of oxygen. This black discoloration develops where the segmented sections of the shell join together. There is a blackening of the melanin pigments in the shell membranes. This blackening appears as black bands where the shell segments overlap, giving the tail a banded (zebra or tiger) appearance. This leaves a tigering appearance. This condition when confined to the shell is not serious, but when it penetrates into the flesh beneath shell, it is unacceptable. Aboard fishing vessels, chemicals such as sodium bisulfite are added to the shrimp when iced to inhibit this development.

d. **Fever Shrimp.** Fever shrimp is a reddish discoloration of the muscle tissue under the shell of shrimp and other crustaceans. It is the result of improper chilling (icing) after the catch. It is more noticeable in white shrimp. The inspector must not confuse fever shrimp with the normal red membrane that separates the muscle tissue from the shell.

e. **Iodoform Shrimp.** Iodoform odor in shrimp is the result of excessive feeding on certain types of seaweed. There is a strong medicine odor and taste in iodoform shrimp. It is common for brown shrimp to have an iodoform taste and odor. However, a pronounced condition is unacceptable as it reduces the palatability for institutional type feeding.

3-11. DETERIORATION OF UNKNOWN CAUSE

In some cases, you may not be able to determine the cause of a deteriorative condition. You should notify the veterinary officer. The veterinary officer will identify the deteriorative condition or he may have you prepare a sample for submission to the medical laboratory. For further information, see subcourse MD0704, Inspection Records and Reports.

3-12. DETERMINING THE AMOUNT, SEVERITY, AND EXTENT OF A DETERIORATIVE CONDITION

After you have determined the deteriorative condition in the waterfood, determine the amount of deteriorative condition present in the product. You, the 91R20, should then determine the severity and extent of the condition. For this, you will use contractual documents or local SOP, as applicable. This information may have already been supplied by the 91R10 veterinary food inspection specialist's inspection reports.

Section II. DETERMINATION OF POTENTIAL HEALTH HAZARDS AND RECOMMENDATIONS

3-13. INTRODUCTION

Determining the existence of any potential health hazard is based upon the deteriorative condition and the amount of product deterioration. A health hazard is defined as any substance that could harm a person's health and/or well-being.

3-14. MICROBIAL PATHOGENS

Depending upon the microorganisms present in the product, microbial spoilage certainly may be a potential health hazard.

a. **Toxicogenic Microorganisms.** The microorganisms listed below are a health hazard in waterfoods:

(1) Vibrio parahaemolyticus**.** These halophilic (salt-loving) bacteria produce a food-poisoning disorder in man. The disorder is a typical gastroenteritis, with diarrhea as the main symptom. Foods that have been incriminated in outbreaks in the US include steamed crabs, crab salad (made from canned crab meat), raw crab, processed lobster, broiled shrimp, roasted oysters, and raw oysters. Outbreaks have been caused by raw products that were inadequately refrigerated and cooked foods that were inadequately heated followed by inadequate refrigeration. In some outbreaks, there was cross-contamination between cooked and raw products.

(2) Clostridium botulinum, Type E. This organism is sometimes called the fish botulism organism. Under suitable conditions, the organism will grow and produce a toxin. The toxin is extremely lethal and may cause death if ingested. The toxin is heat sensitive and will normally be destroyed by proper cooking. The organism can grow in improperly processed canned fish, in vacuum-packaged products, and in some smoked products.

b. **Factors in Maintaining the Wholesomeness of Waterfoods.** Fresh waterfoods in general owe their freedom from food poisoning risk to three factors. They are:

(1) The absence of most food poisoning bacteria in the natural flora (in contradistinction to fowl, in which Salmonella organisms occur naturally).

(2) The normal practice of holding fish products at low temperatures.

(3) The controlling influence of the normal and putrefactive spoilage flora on stored fish.

c. **Growth of Spoilage Flora.** Food poisoning organisms will not, in general, grow significantly at low temperatures (below 50ºF; 10ºC), but the normal flora, since it is primarily psychrophilic in nature, will grow quite actively. In situations where the temperature is high enough to permit growth of dangerous organisms, the natural flora will, in most cases, grow very much faster so that the potential pathogens are swamped and eventually die out. There may even be a positively lethal effect on such pathogens from the competitive growth of the spoilage flora.

3-15. OXIDATIVE RANCIDITY

If this deteriorative condition is present in severe quantities, a potential health hazard may exist. High levels of malonaldehyde are found in rancid foods. Malonaldehyde is a decomposition product of polyunsaturated fatty acids. This chemical has been reported to be carcinogenic. Foods with sufficient malonaldehyde to cause problems will have such an off-odor and off-flavor that a person would not normally consume that product. However, a potential health hazard does exist.

3-16. DEHYDRATION

This deteriorative condition does not present a potential health hazard. However, in severe cases, it may increase oxidative rancidity of the product.

3-17. WATERMARKING

Watermarking does not present a health hazard. However, salmon with extremely dark, thick, colored skin and definite mottled and faded flesh are not considered acceptable for human consumption.

3-18. DISEASED SCALLOPS

Diseased scallops present a potential health hazard.

3-19. FOREIGN MATERIAL

Foreign material must exceed certain formal guidelines to present a potential health hazard. The type of foreign material found on the product will also determine the health hazard potential.

3-20. PARASITES

Generally, parasites do not constitute a major health hazard since most are not transmissible to man or are usually destroyed during freezing or cooking. Identity of the parasite must be confirmed by the veterinary officer to determine if a potential health hazard exists.

3-21. DETERIORATION OF UNKNOWN CAUSE

If the cause of the deterioration is unknown, the veterinary officer will make the decision as to whether a potential health hazard is present or not.

3-22. RECOMMENDATIONS

a. **Inspector Action.** Utilizing all known information regarding the deteriorative waterfoods, you will make recommendations concerning the product. Complete the appropriate forms and reports in accordance with local SOP.

b. **A Potential Health Hazard.** If you determine that a potential health hazard exists or is suspected to exist, you must notify the veterinary officer.

c. **Destination/Procurement Inspection.** If you find no potential health hazard found in a destination/procurement inspection, you must determine the compliance of the product based upon comparison of known information with information taken from the inspection data packet or local SOP.

d. **Surveillance Inspection.** If you find no health hazard in a surveillance inspection, you must determine serviceability after comparing known information with standards established by DLA 4155.37, Appendix S, DPSC Manual 4155.7, AR 40-656, or local SOP, as applicable. The following factors must be considered:

(1) Suitability for intended use.

(2) Expected usage date.

(3) Amount of product in storage.

(4) Storage environment.

e. **Disposition of Sample.** Following the determination of recommendations, you must determine the disposition of the sample. For further information, see subcourse MD0694, Inspection Records and Reports.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or indicates whether the statement is true or false or by writing the answer in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the exercises and check your answers. For each incorrect answer, reread the material referenced after the answer.

1. List four colors that may indicate microbial spoilage in waterfoods.

   a. _____

   b. _____

   c. _____

   d. _____

2. List six odor changes that may be associated with microbial deterioration in waterfoods.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

   f. _____

3. List four changes in texture that may be associated with microbial deterioration in waterfoods.

   a. _____

   b. _____

   c. _____

   d. _____

4. If microbial spoilage is suspected, what will the response of the inspector be?

   a. CAUTION. The inspector should NOT _____.

   b. ACTION. The inspector should _____ for further examination of the product.

5. List the four condition characteristics of fresh, stale, or putrid fish that apply to fillets and steaks.

   a. _____

   b. _____

   c. _____

   d. _____

6. Honeycombing, as seen in canned tuna, is a deteriorative condition caused by _____ _____ _____ present prior to the canning of the tuna. It is evidenced by _____, _____ _____ in the surface flesh, which may extend through two or more _____. A _____ _____ can also be detected.

7. Green-gilled oysters result from the accumulation in the _____ and _____ of a _____ or _____ _____derived from certain types of _____.

8. The parasitic protozoa Microspordia is the cause of the deteriorative condition known as:

   a. Honeycombing.

   b. Pink or red oysters.

   c. Green-gilled oysters.

   d. Cotton or milky shrimp.

   e. Iodoform shrimp.

9. Diatoms are a family of minute algae that cause the deteriorative condition known as:

   a. Dark gray scallops.

   b. Pink or red oysters.

   c. Green-gilled oysters.

   d. Cotton or milky shrimp.

   e. Black spot in shrimp.

10. The flesh of a fresh fish fillet will characteristically be firm, elastic, and tight on the bones. Finger impressions do not remain.

    a. True.

    b. False.

11. A slight off-odor (fishy odor) is characteristic of putrid fish.

    a. True.

    b. False.

12. Which appearance is characteristic of a fresh fish?

    a. Dark brown appearance.

    b. Dull and moist appearance.

    c. Dull and dry appearance.

    d. Bright bloom.

13. Surface slime of a stale fish may be described as:

    a. Clear, odorless.

    b. Dry and sticky with an offensive odor.

    c. Devoid of color or dark, viscous, with slight odor.

    d. Dirty brown with no odor.

14. The slightly off-odor in stale fish is caused by:

    a. Ammonia.

    b. Hydrogen sulfide.

    c. Malonaldehyde.

    d. Triethylamine.

15. The most common type of spoilage organisms in fish are gram-positive psychrophilic bacteria.

    a. True.

    b. False.

16. Select the deteriorative (microbial) condition in salted fish that the species Sporendonema is responsible for.

    a. Cheesy odor.

    b. Pink color.

    c. Red growth.

17. Off-odor of fresh fish may be caused by which of the following organisms?

    a. Pseudomonas.

    b. Achromobacter.

    c. Proteus.

    d. Vibrio.

    e. "a," "c," or "d" above.

18. Red oysters are due to:

    a. E. coli.

    b. Proteus vulgaris.

    c. Salmonella marcescens.

    d. Serratia marcescens.

19. Watermarking is a physiological change particular to salmon. Two changes occur.

    a. A skin color change (_____ _____-_____ to _____ _____-_____) along with a _____ of the skin.

    b. _____ and _____ _____ of the flesh.

20. The following color change indicates oxidative rancidity in fish:

    a. Pink to red discoloration.

    b. Dark brown to black discoloration.

    c. Light yellow to brown discoloration.

    d. Light brown to black discoloration.

21. Fish products with 16 percent fat or more will normally not be affected by oxidative rancidity.

    a. True.

    b. False.

22. Parasites in fish may be detected by:

    a. Candling.

    b. UV light.

    c. High salt concentration.

    d. All of the above.

23. Which of the following parasites are disease-causing in humans?

    a. Porracaecum decipiens.

    b. Prosorphyncus.

    c. Diphyllobothrium latum.

    d. Sphyrion lumpi.

24. What parasite has caused major specification revision for commercially important parasites of fish?

    a. Broad or European tapeworm.

    b. Copepod.

    c. Flatworm.

    d. Codworm.

    e. Roundworm larvae of the Anisakidae family.

25. Which of the following is a disease-causing parasite of humans that is found in saltwater fish that come to US markets from many parts of the world?

    a. Broad or European tapeworm.

    b. Copepod.

    c. Flatworm.

    d. Codworm.

    e. Roundworm larvae of the Anisakidae family.

26. During the inspection of oysters, a tolerance of _____ is allowed.

    a. One spawny oyster per lot.

    b. Two spawny oysters per gallon.

    c. One spawny oyster per quart.

    d. One spawny oyster per pint.

27. During a surveillance inspection of oysters, a pH of 5.9 was determined. What disposition recommendation for these oysters should be made?

    a. Normal issue.

    b. Immediate issue.

    c. Hold.

    d. Condemn.

28. Diseased scallops may be recognized by:

    a. Large red nodules on the internal surface that contains no fluid.

    b. Small pink nodules that contain a puslike fluid.

    c. Small green to yellow nodules that have a solid texture.

    d. Small pink nodules that have a solid texture.

29. A deteriorative condition in shrimp that causes black discoloration where the segmented sections of the shell join together is:

    a. Tigering.

    b. Fever shrimp.

    c. Iodoform shrimp.

    d. Cotton or milky shrimp.

30. Which species of halophilic bacteria may cause food poisoning when the affected waterfood is eaten?

    a. Vibrio suis.

    b. Vibrio paratyphoid.

    c. Vibrio parahaemolyticus.

    d. Proteus vulgaris.

31. What is the fish botulism organism?

    a. Clostridium botulinum Type A.

    b. Clostridium perfringens Type C.

    c. Clostridium botulinum Type C.

    d. Clostridium botulinum Type E.

    e. Gonyaulax catanella.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. Color changes. Red, pink, chocolate brown, yellowish green, black, or brown. (para 3-2d)

2. Odor changes. Wet dog, wet hair, dishraggy, fruity, hydrogen sulfide, ammonia, yeasty, sweet, brine-like, fecal, milky, soapy, putrid, sour, musty, or muddy. (para 3-2e)

3. Changes in texture. Jellylike, turbid, honeycombed, soft, bubbly, foamy, or slimy. (para 3-2f)

4. a. taste the product.
   b. contact the veterinary officer. (para 3-2c)

5. Appearance
   Odor
   Flesh
   Blood (figure 3-1)

6. Honeycombing is a deteriorative condition caused by gas-forming bacteria present prior to canning of the tuna. It is evidenced by small, pitted holes in the surface flesh, which may extend through two or more layers. A sharp taste can also be detected. (para 3-2i)

7. Green-gilled oysters result from the accumulation in the gills and mantle of a bluish or greenish pigment derived from certain types of diatoms. (para 3-2k)

8. d (para 3-2l)

9. c (para 3-2k)

10. a (figure 3-1)

11. b (figure 3-1)

12. d (figure 3-1)

13. c (figure 3-1)

14. d (figure 3-1)

15. b (para 3-2h)

16. c (figure 3-2)

17. e (figure 3-2)

18. d (figure 3-2)

19. Watermarking is a physiological change particular to salmon. Two changes occur.

    a. A skin color change (light pink-brown to dark red-brown) along with a thickening of the skin.

    b. Mottling and color fading of the flesh. (para 3-4)

20. c (para 3-6c)

21. b (para 3-6b)

22. d (para 3-8c)

23. c (para 3-8d)

24. d (para 3-8e(3))

25. e (para 3-8d(2))

26. d (para 3-9a)

27. b (para 3-9d)

28. b (para 3-10b)

29. a (para 3-10c)

30. c (para 3-14a(1))

31. d (para 3-14a(2))

End of Lesson 3

LESSON ASSIGNMENT

LESSON 4	Deterioration of Dairy Products and Shell Eggs.
TEXT ASSIGNMENT	Paragraphs 4-1 through 4-30.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

4-1. Given a description of a deteriorative change in dairy products, identify the condition and the cause of the change.

4-2. Given a description of a deteriorative change in dairy products, determine whether or not the presence of a health hazard exists.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 4

DETERIORATION OF DAIRY PRODUCTS AND SHELL EGGS

Section I. CAUSES OF OFF-FLAVORS IN MILK

4-1. GENERAL INTR0DUCTION

a. **Duty of 91R20.** As a 91R20 veterinary food inspection specialist, you must verify the presence of deteriorative conditions in dairy products. As appropriate, you will confirm inspection findings indicating the presence of deteriorative subsistence. Deteriorative conditions include abnormal color, off-odor, abnormal texture or consistency, off-flavor, foreign material, and others.

b. **Duty of 91R10.** The 91R10 veterinary food inspection specialist's findings do not identify the deteriorative condition. Rather, the 91R10 notes abnormalities of the inspected product which may or may not indicate the presence of a deteriorative condition.

c. **Classifying Off-Flavors.** The following paragraphs of this section classify off-flavors in milk according to their causes.

4-2. HEAT-INDUCED FLAVORS

There are four kinds of heat-induced flavor alterations: cooked or sulfurous, heated or rich, caramelized, and scorched.

a. **From Pasteurization.** Pasteurization imparts a slight cooked or sulfurous flavor to milk. The flavor is more pronounced if higher temperatures are used.

b. **From Refrigerator Storage.** A rich or heated flavor results after milk has been stored at refrigerator temperatures for several days.

c. **From an Autoclave.** Retorted and autoclaved milk often has a caramelized flavor.

d. **From High Temperature Processing.** A scorched flavor can result from exceptionally large amounts of "burn on" in a heat exchanger. This flavor also occurs in dry milk powders subjected to abnormally high temperature processing.

4-3. LIGHT-INDUCED FLAVORS

Milk exposed to various forms of radiant energy develops off-flavors. For example, off-flavors may develop when milk is exposed to sufficient direct sunlight, fluorescent light, or even diffused daylight. The light-induced flavor has two distinct components. One is a burnt or "sunlight" flavor which develops rapidly and has been attributed to the degradation of protein components. The second component is similar to oxidized flavor which seems to develop more slowly. Recently, the widespread use of plastic milk containers has increased the incidence of the light-induced flavor.

4-4. LIPOLYZED FLAVOR

Several terms have been used to describe this flavor. Rancid, the most commonly used, is ambiguous since it is also used to describe the flavor defect resulting from lipid oxidation. The descriptive terms goaty, soapy, and butyric also have been used. It is recommended that lipolyzed flavor be used to denote the lipase-induced flavor defect.

4-5. MICROBIAL FLAVOR

Serious flavor defects in both raw and pasteurized milk may result from an accumulation of the products of bacterial metabolism. These are produced by the actions of contaminating organisms on the constituents of milk. See paragraph 4-10d for additional information.

4-6. OXIDIZED FLAVOR

This undesirable flavor is often in milk and results from a reaction between oxygen and fats. Milk varies considerably in its susceptibility to this defect.

4-7. TRANSMITTED FLAVORS

Milk flavors may arise by passage of substances from the cow's feed or surroundings while the milk is still in the udder. This transfer may be via the respiratory system and/or digestive system and bloodstream. Some of these off-flavors are described as feed flavor, weed flavor, cowy flavor, and barny flavor.

4-8. MISCELLANEOUS FLAVORS

a. **Definition.** This group of flavors includes those flavors that either cannot be attributed to a specific cause or cannot be specifically defined in sensory terms.

b. **Absorbed Flavor.** The term absorbed is applied to those flavors (odors) that are absorbed from the environment. The evidence indicates that fat-soluble substances, such as turpentine, are absorbed readily. The milking and milk storage areas should be kept free of these odors.

c. **Astringent Flavor.** The term astringent has been used to describe a dry, puckery oral sensation which involves the sense of touch or feel rather than taste. Astringency has been associated with milk products that have been processed at high temperatures.

d. **Bitter Flavor.** This flavor is often caused by proteolysis, which can form amino acids having a bitter flavor. Bitter flavor may be caused by lipolysis or by cows eating certain weeds, such as bitterweed.

e. **Chalky Flavor.** Chalky flavor has been described as a sensation suggesting finely divided, insoluble powder particles. This flavor may be due to improper pasteurization and homogenization procedures.

f. **Chemical Flavors.** Chemical flavors are caused by contamination of milk with chemicals associated with cleaners, sanitizers, and disinfectants. Chemical flavors may be transferred to milk indirectly from food contact surfaces, packaging materials, or residues of substances used on food equipment.

g. **Flat Flavor.** This defect is characterized by a lack of flavor and a tactile sensation of thinness.

h. **Foreign Flavor.** This flavor is normally referred to as abnormal flavor.

i. **Lack of Freshness.** This term is used to describe milk that does not have the complete, pleasing taste of high-quality fresh milk.

j. **Salty Flavor.** This defect is identified easily by tasting. It is most commonly in milk from cows in late lactation and occasionally from milk of cows with mastitis.

Section II. DETERIORATIVE CONDITIONS IN DAIRY PRODUCTS

4-9. INTRODUCTION

You, the 91R20 veterinary food inspection specialist, must identify the deteriorative conditions found in dairy products. These conditions are discussed in this section.

4-10. MICROBIAL SPOILAGE

a. **General.** Milk obtained from the cow may not be sterile. During and after milking, the milk is subjected to organisms from various sources. However, contaminated equipment used to handle, transport, store, and process the milk seems to be the main source of organisms.

b. **Examination of Product.** You must examine the product for abnormal color(s), abnormal odor(s), abnormal flavor(s), and abnormal texture or consistency which may indicate microbial deterioration. Microbial spoilage may be caused by bacteria, mold, and/or yeasts. The particular color, odor, flavor, or texture/consistency change(s) involved will depend upon the type or species of microorganisms involved. If microbial spoilage is suspected, DO NOT TASTE THE PRODUCT. You should contact the veterinary officer for further examination of the product.

c. **Color Changes.** The following color changes may indicate microbial spoilage: blue, bluish gray, pink, yellow, red, and brown.

d. **Odor and Flavors.** The following odors and flavors may be associated with microbial deterioration of dairy products: sour or acid, bitter, burnt or caramel, soapy, malty, rancid, fishy, fruity, oxidized, alcoholic, and putrid. Although bacteria may be responsible for a number of different flavor defects in both raw and pasteurized milk, only those defects described as acid, malty, and fruity can be recognized as being of microbial origin by sensory perception alone. The flavors described as stale, barny, unclean, bitter, foreign, rancid, and feedy (like animal feed) can be caused by bacteria, but determination of the actual cause is often difficult without bacteriological analyses because of the similarity of these flavors to flavors due to other causes.

(1) Acid flavor. Because of the universal distribution of Streptococcus lactis in the environment of milk production, most milk is unintentionally inoculated with this organism immediately after milking. If the milk is not cooled immediately to 4.4ºC (40ºF) or below, it eventually will develop an acid taste due to proliferation of the organism and its conversion of lactose to lactic acid. The development of lactic acid in milk is accompanied by an odor usually described as sour. Since S. lactis is destroyed by proper pasteurization, acid development in milk subsequent to pasteurization is not likely. However, pasteurization will not improve the flavor of raw milk if acid already has developed.

(2) Malty flavor. A flavor and aroma which in the past has been described as cooked, burnt, caramel, or malty, may develop in raw milk as a result of the metabolism of S. lactis subspecies maltigenes. This organism enters milk through contact with improperly sanitized equipment during production.

(3) Fruity flavor. The aroma, which may develop in pasteurized milk and other processed dairy products as a result of Pseudomonas fragi, has been described as strawberry-like or fruity. P. fragi, a psychrotrophic water and soil organism, is distributed widely in dairy environments. The organism is very heat sensitive, and its presence in pasteurized products is due to post-pasteurization contamination. Strains of Bacillus have also been isolated from milk with a fruity flavor. These spore-forming organisms may be the cause of flavor defects in aseptically packaged "sterilized" milk and fluid milk products.

(4) Unclean, bitter, and putrid flavors. Unclean and bitter flavors may be due to other causes. However, unclean, bitter, and putrid flavors are often caused by growth of psychrophilic organisms in pasteurized milk. The resulting flavor defects usually become evident upon extended storage of milk.

e. **Defects of Butter.** One of the main defects of butter is rancidity. This can be due to oxidation as well as to microbial growth. Molds are able to grow on the surface of butter. Putrid, proteolytic, and fruity flavors in butters are caused by psychrophilic bacteria. Surface taint and yeasty butter are other defects of this product caused by microorganisms.

f. **Defects of Cottage Cheese.** In cottage cheese, the flavor defects of milk may be accompanied by a gelatinous or tapioca curd formation. Pseudomonas fragi and Alteromonas putrefaciens have been associated with a slimy curd defect on the surface of cottage cheese. A fruity, putrid, or rancid odor and a fruity or bitter flavor may accompany this defect. Surface discoloration of cottage cheese may occur due to the growth of the pigment Flavobacterium. E. coli can cause barny or unclean flavors and, if the cottage cheese is held at room temperature, the organism can cause a gassy defect. The yeast Rhodotorula produces pink spots which may become a pink slime. Torulopsis also produces a slime, but it is yellow. Geotrichum produces off-white, tan, or yellow surface discolorations.

g. **Defects of Italian Cheese.** A pink discoloration of Romano and other Italian cheese varieties occurs as a uniform band of color near the cheese surface or as discoloration throughout the entire cheese. This discoloration is due to Lactobacillus helveticus and L. bulgaricus.

h. **Summary.** A summary of microbial conditions of dairy products may be seen in figure 4-1.

PRODUCT	CONDITION
Pasteurized milk	Rancidity, Ropy or Slimy, Sour, Bitter, Fruity
Canned milk	Swelling, Gas
Butter	Surface Taint
Cheese	Moldy
Cottage cheese	Slimy Curd, Putrid Odor, Gelatinous, Fruity
Yogurt	Yeasty

Figure 4-1. Microbial conditions of dairy products.

4-11. OXIDATIVE RANCIDITY

Examine the product for odor/flavor changes which may indicate oxidative rancidity.

a. **Cause.** This undesirable flavor results from a reaction between oxygen and lipids (fats). Milk from some cows develops this defect so quickly and without any abuse that it is said to oxidize spontaneously. This oxidation may be caused by the catalytic action of copper ions. Contamination or fortification of milk with iron may also accelerate this reaction.

b. **Terms Used.** The oxidation of dairy products leads to flavors termed cardboard-like, tallowy, or oily.

c. **Absence of Change in Color or Texture.** No color or textural changes are evident in the oxidative rancidity of dairy products.

d. **Reference.** A discussion of oxidative rancidity may be found in paragraph 1-14a.

4-12. HYDROLYTIC RANCIDITY

Examine the product for odor/flavor changes which may indicate hydrolytic rancidity.

a. **Definition.** Hydrolytic rancidity is the breakdown of fats by enzymes. This lipolysis requires the presence of water and may be mediated by heat, acidity, alkalinity, or any of the lipolytic enzymes native to the food or introduced by microorganisms. From dairy fats, the hydrolytic release of butyric, caproic, and caprylic acids produces odors which are usually described as goaty.

b. **Rancid Flavor.** The sharp, biting, acrid flavor indicating this condition may be referred to as a rancid flavor. The flavor may vary depending upon the stage of the reaction.

4-13. DEHYDRATION

Examine the product for textural changes and darkening of the product which may indicate dehydration.

a. **Definition.** Dehydration is a loss of water from a product such as cheese. Dehydration is usually due to improper storage conditions.

b. **Color.** Dehydration of a frozen product dries out the surface. Usually the product darkens.

c. **Texture.** The texture of a dehydrated product is dry, wrinkled, hard, and/or leathery.

4-14. FREEZE DAMAGE

Examine the product for ice crystals. Separation of the components may also indicate freeze damage.

a. **Definition.** Freeze damage occurs in products not normally sold in the frozen state. Container expansion, ice crystals, and separation of the components of the product indicate freeze damage.

b. **Texture.** Changes in texture caused by freeze damage include separation and/or formation of a watery and crumbly product.

4-15. FOREIGN MATERIAL

Examine the product for any extraneous matter which does not organically belong where found, which has been introduced from the outside, or which does not naturally occur in the quantity found at the location examined. This can include body parts (from rodents, insects, and/or birds), excreta, chemical compounds, sawdust, and wood.

4-16. DETERIORATION OF UNKNOWN CAUSE

Examine the product for deterioration of unknown cause. If it is found, notify the veterinary officer. The veterinary officer will identify the condition, or he may have you prepare a sample of the product for submission to the medical laboratory. For further information, see subcourse MD0704, Inspection Records and Reports.

4-17. DETERMINING THE AMOUNT, SEVERITY, AND EXTENT OF A DETERIORATIVE CONDITION

After you have determined the deteriorative condition in the dairy products, determine the amount of deteriorative condition present in the product. You, the 91R20, will then determine the severity and extent of the condition. For this, you will use contractual documents or local SOPs, as applicable. This information may have already been supplied by the 91R10 veterinary food inspection specialist's inspection reports.

Section III. DETERMINATION OF POTENTIAL HEALTH HAZARDS IN DAIRY PRODUCTS

4-18. INTRODUCTION

Determine the existence of any potential health hazard, based upon the deteriorative condition and the amount of product deterioration. A health hazard is defined as any substance that could harm a person's health and/or well-being.

4-19. MICROBIAL PATHOGENS

Depending upon the microorganisms present in the product, microbial spoilage certainly may be a potential health hazard. The following microorganisms may be a health hazard in dairy products.

a. **Clostridium botulinum.** Dairy products are rarely involved in outbreaks of botulism since most dairy products are consumed in a fresh state rather than canned.

b. **Salmonella Species.** Raw milk has been the carrier in outbreaks throughout the world. One outbreak in the US was due to ingestion of pasteurized milk. Affected ice cream was, in most cases, contaminated by infected shell eggs. The risk of Salmonella organisms in dairy products is rather low.

c. **Escherichia coli.** Certain strains of E. coli may cause enteritis in humans. In 1971, an outbreak due to enteropathogenic E. coli in imported cheese resulted in several hundred reported cases. In other countries, outbreaks have been associated with consumption of dairy products. The symptoms of illness are diarrhea, fever, nausea, and cramps.

d. **Staphylococcus Species.** These organisms, especially S. aureus, may be present in the milk of cows suffering from acute mastitis. It is the most common pathogenic organism found in raw milk, but most cases of infection may be traced to a human carrier. Some organisms, especially the lactobacilli, inhibit the growth of staphylococci. Staphylococcal food poisoning has occurred through consumption of cheese which had not developed acidity in a normal manner. Evidently, the acid-producing bacteria, such as the lactobacilli, had not developed and were thus not available to inhibit the growth of contaminating staphylococci.

e. **Mycobacterium bovis.** Infected raw milk is the chief means by which milk-borne tuberculosis is transmitted to man. The organism is one of the most heat-resistant of the nonspore-forming pathogenic bacteria, but fortunately it is destroyed by pasteurization. Milk-borne cases of tuberculosis are rare today. Such cases were more common when milk was not pasteurized and when tubercular cows were not eliminated from the herds.

f. **Brucella Species.** Brucellosis is the name applied to the disease caused by members of the group of organisms known as Brucella. This disease is spread by contact with infected material or by consumption of raw milk from diseased animals. Brucellosis is most commonly found in rural areas where raw milk is used. The causative organisms are destroyed easily when milk is pasteurized.

g. **Leptospira Species.** Leptospirosis is a spirochetal infection. Mild attacks in man resemble influenza. Leptospira organisms have been found in the milk of diseased cows. There is some doubt that such milk is a source of the disease in man. As milk has a lytic action on the organisms, they are gradually disintegrated.

h. **Coxiella burnetii.** This organism causes Q fever, a pneumonia-like disease of rickettsial origin. The organism has been isolated from raw milk. Butter made from unpasteurized milk has also been found to be a source of the disease. This organism is one of the organisms most resistant to pasteurization. Therefore, proper relationships of time and temperature must be carefully observed to ensure its destruction.

4-20. OXIDATIVE RANCIDITY

If this condition exists in severe quantities, a potential health hazard may exist. For a discussion of the hazard of oxidative rancidity in foods, see paragraph 2-14.

4-21. HYDROLYTIC RANCIDITY

If this condition exists in severe quantities, a potential health hazard may exist.

4-22. DEHYDRATION

Dehydration does not present a potential health hazard. This condition, in severe cases, may make the item unsuitable for its intended use.

4-23. FREEZE DAMAGE

Freeze damage does not present a potential health hazard. This condition, in severe cases, may make the item unsuitable for its intended use.

4-24. FOREIGN MATERIAL

Foreign material must exceed certain formal guidelines to present a potential health hazard. The type of foreign material found on the product will also determine the health hazard potential.

4-25. DETERIORATIVE CONDITION OF UNKNOWN CAUSE

In the case of a deteriorative condition of unknown cause, the veterinary officer will make the decision as to whether a potential health hazard is present or not.

Section IV. DETERIORATIVE CONDITIONS IN SHELL EGGS

4-26. INTRODUCTION

a. **Responsibility.** As a 91R20 veterinary food inspection specialist, you must verify the presence of deteriorative conditions in shell eggs.

b. **Storage and Handling.** Because shell eggs are delicate, they must be stored under controlled temperature and must be handled with care. Rough handling may cause the shells to crack or leak or the air cells inside the eggs may break loose and move about.

c. **Importance of Humidity Control.** Humidity must be maintained at an accurate level. When it is too high, moisture develops on the eggs and sometimes causes mold to grow inside the shell eggs. When it is too low, the shell eggs may dehydrate on the inside.

d. **Potential Deterioration During Storage.** Because deterioration can take place on the inside of shell eggs, the supply in storage may be in an advanced stage of deterioration before the problem is discovered.

4-27. MICROBIAL SPOILAGE

When laid, the contents of the shell egg are generally free from bacteria. The shell egg contents are protected by the shell and associated membranes and chemical inhibitors in the egg albumen. Some of the components in the albumen that provide an unfavorable medium for microbial growth include lysozyme, conalbumin, ovomucoid, avidin, riboflavin, and others. (Although shell eggs have built-in natural protection as just described, Salmonella has been found in freshly laid eggs. Therefore, it must be assumed that all shell eggs are contaminated with this bacterium.) Deteriorative conditions due to microbial growth that cause shell eggs to become inedible follow.

a. **Black Rot.** When viewed with a candling light, shell eggs with black rot are virtually opaque. When broken out, the egg content has either a gelatinous yolk, blackened throughout with a grey, watery albumen, or a dark brown, mealy yolk with a dark brown albumen. The bacteria associated with this type of spoilage are species of Proteus and Aeromonas.

b. **White Rot.** With white rot, threadlike shadows may be seen in the thin white. In later stages, the yolk appears severely blemished when the shell egg is viewed with the candling light. Upon opening, the egg yolk shows a crusted appearance and

frequently has a fruity odor. Various organisms have been associated with this rot, including Citrobacter, Salmonella, and Alcaligenes.

c **Sour Eggs.** On candling, sour eggs show a weak white and murky shadow around an off-center, swollen yolk. These eggs are also called fluorescent or fluorescent green rot. A fluorescent green pigment throughout the albumen is produced by Pseudomonas species.

d. **Green Whites.** Green whites of broken out shell eggs exhibit fluorescence when observed with UV light. Shell eggs with green white may or may not have a sour odor. This defect is caused mainly by Pseudomonas fluorescens.

e. **Musty Eggs.** These shell eggs appear clear and free from foreign material when candled. The musty odor may be caused by odors in the atmosphere being absorbed by the egg contents. Also, some microorganisms occasionally invade shell eggs and produce a musty odor.

f. **Moldy Eggs.** Mold growth is visible as spots on the shell, in checked areas of the shell, or inside the egg. The mold contamination of shell eggs seem to be due to the reuse of moldy packing materials. Several molds, such as Penicillium, Alternaria, and Rhizopus, can grow on shell eggs.

g. **Red Rot.** With red rot, the egg whites are stained red throughout and the yolks are surrounded by custard-like material. An ammoniacal to putrid odor may occur. Serratia marcescens is the usual cause of red rot.

h. **Custard Rot.** In this rot, the yolk is encrusted with custard-like material and occasionally flecked with olive green pigment. The albumen becomes thin with an orange tint. These shell eggs may have a slightly putrid to putrid odor. Citrobacter and Proteus vulgaris have been associated with this type of spoilage.

i. **Other Rots.** Alcaligenes has been the organism causing both yellow rots and green rots. These rots are similar in odor and in the appearance of albumen. However, the yolk is dark yellow in yellow rot and dark green to black in green rots.

4-28. POTENTIAL HEALTH HAZARDS IN SHELL EGGS

A potential health hazard exists for all of the previously discussed deteriorative conditions of shell eggs. Some of the microorganisms that may cause foodborne illness due to shell eggs are as follows.

a. **Salmonella species.** Shell eggs and egg products are an important source of Salmonella. However, pasteurization of egg products has eliminated this product as a vehicle for this illness. Ice cream has been contaminated by infected shell eggs.

b. **Staphylococcus species.** Shell eggs have been involved in a small percentage of the staphylococcal intoxications in the US However, the potential health hazard still exists.

Section V. RECOMMENDATIONS REGARDING DETERIORATION OF DAIRY PRODUCTS AND SHELL EGGS

4-29. GENERAL

a. **Inspector Action.** Utilizing all known information regarding the deteriorative dairy products and/or shell eggs, you will make recommendations concerning the product. Complete the appropriate forms and reports in accordance with local SOP.

b. **A Potential Health Hazard.** If you determine that a potential health hazard exists or is suspected to exist, you must notify the veterinary officer.

4-30. INSPECTIONS

a. **Destination/Procurement Inspections.** If there is no potential health hazard found on a destination/procurement inspection, you must determine the compliance of the product based upon comparison of known information with information taken from the inspection data packet or local SOP.

b. **Surveillance Inspections.** If there is no health hazard found on a surveillance inspection, you must determine serviceability after comparing known information with standards established by DLA 4155.37, Appendix S; DPSC Manual 4155.7; AR 40-656; AR 40-70; or local SOP, as applicable. The following factors must be considered:

(1) Suitability for intended use.

(2) Expected usage date.

(3) Amount of product in storage.

(4) Storage environment.

c. **Disposition of Sample.** Following the determination of recommendations, you must determine the disposition of the sample. For further information, see subcourse MD0704, Inspection Records and Reports.

Continue with Exercises

EXERCISES, LESSON 4

Follow each set of instructions. After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each incorrect answer, reread the material referenced after the answer.

INSTRUCTIONS. In exercises 1 through 10, match each off-flavor of milk in Column A with another term for it in Column B. Terms in Column B may be used more than once.

COLUMN A			COLUMN B	
1.	____	Weed flavor.	a.	Heated flavor.
2.	____	Astringent flavor.	b.	Light-induced flavor.
3.	____	Soapy flavor.	c.	Lipolyzed flavor.
4.	____	Rich flavor.	d.	Autoclaved milk flavor.
5.	____	Sulfurous flavor.	e.	Oxidized flavor.
6.	____	Barny flavor.	f.	Transmitted flavor.
7.	____	Sunlight flavor.	g.	Dry, puckery flavor.
8.	____	Goaty flavor.	h.	Cooked flavor.
9.	____	Caramelized flavor.	i.	Abnormal flavor.
10.	____	Foreign flavor.		

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or by writing the answer in the space provided.

11. The most common microorganism found in milk is:

    a. Staphylococcus aureus.

    b. Clostridium perfringens.

    c. Streptococcus lactis.

    d. Streptococcus cremoris.

12. Fruity flavor in milk is mainly due to the following microorganism:

    a. Pseudomonas aeruginosa.

    b. Pseudomonas fragi.

    c. Streptococcus lactis.

    d. Staphylococcus aureus.

13. One of the main defects of butter is _____. This can be due to _____ as well as to _____ _____ .

14. A pink discoloration in Romano and other Italian cheeses is due to:

    a. Clostridium species.

    b. Streptococcus species.

    c. Lactobacillus species.

    d. Bacillolactis species.

15. In hydrolytic rancidity, the release of _____ acid, _____ acid, and _____ acid produces odors which are usually described as goaty.

16. Several diseases are transmitted by infected raw milk. They include all the following **EXCEPT**:

    a. Tuberculosis.

    b. Q fever.

    c. Botulism.

    d. Brucellosis.

INSTRUCTIONS. In exercises 17 through 20, match each type of microbial spoilage of shell eggs in Column I with its cause in Column II. Each cause in Column II may be used only once.

	COLUMN I		**COLUMN II**
17.	____	Black rot.	a. Salmonella
18.	____	Moldy eggs.	b. Clostridium.
19.	____	Sour eggs.	c. Staphylococcus.
20.	____	White rot.	d. Alternaria.
			e. Proteus.
			f. Pseudomonas.

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or by writing the answer in the space provided.

21. The microorganism that causes yellow rot and green rot in shell eggs is:

    a. Alternaria.

    b. Aeromonas.

    c. Citrobacter.

    d. Alcaligenes.

22. Select the deteriorative condition of broken out shell eggs that exhibits fluorescence when observed with UV light.

    a. Custard rot.

    b. Red rot.

    c. Green whites.

    d. Black rot.

23. The microorganism most likely to cause foodborne illness due to shell eggs is:

    a. Staphylococcus.

    b. Salmonella.

    c. Brucella.

    d. Pseudomonas.

24. Select the off-flavor of milk that is caused by proteolysis, lipolysis, or the ingesting of certain weeds.

    a. Barny flavor.

    b. Absorbed flavor.

    c. Chalky flavor.

    d. Bitter flavor.

    e. Butyric flavor.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 4

1. f (para 4-7)
2. g (para 4-8c)
3. c (para 4-4)
4. a (para 4-2b)
5. h (para 4-2a)
6. f (para 4-7)
7. b (para 4-3)
8. c (para 4-4)
9. d (para 4-2c)
10. i (para 4-8h)
11. c (para 4-10d(1))
12. b (para 4-10d(3))
13. rancidity; oxidation; microbial growth (para 4-10e)
14. c (para 4-10g)
15. butyric; caproic; caprylic (para 4-12a)
16. c (para 4-19a)
17. e (para 4-27a)
18. d (para 4-27f)
19. f (para 4-27c)
20. a (para 4-27b)

21. d (para 4-27i)

22. c (para 4-27d)

23. b (para 4-28a)

24. d (para 4-8d)

End of Lesson 4

LESSON ASSIGNMENT

LESSON 5	Deterioration of Fresh Fruits and Vegetables.
TEXT ASSIGNMENT	Paragraphs 5-1 through 5-14.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

5-1. Given a description of a deteriorative change in fresh fruits and vegetables, identify the condition and the cause of the change.

5-2. Given a description of a deteriorative change in fresh fruits and vegetables, determine whether or not the presence of a health hazard exists.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 5

DETERIORATION OF FRESH FRUITS AND VEGETABLES

Section I. DETERIORATIVE CONDITIONS IN FRESH FRUITS AND VEGETABLES

5-1. INTRODUCTION

a. **Duty of 91R20.** As a 91R20 veterinary food inspection specialist, you must verify the presence of deteriorative conditions in fresh fruits and vegetables (FF&V). As appropriate, you will confirm inspection findings indicating the presence of deteriorative subsistence. Deteriorative conditions include abnormal color(s), off-odor(s), abnormal texture(s), off-flavor(s), foreign material, and others.

b. **Duty of 91R10.** The 91R10 veterinary food inspection specialist's findings do not identify the deteriorative condition. Rather, he notes abnormalities of the inspected product which may or may not indicate the presence of a deteriorative condition.

c. **General.** You, the 91R20 veterinary food inspection specialist, must identify the deteriorative conditions in fresh fruits and vegetables. These conditions are discussed in this section.

5-2. MICROBIAL SPOILAGE OF FRESH FRUITS

a. **General.** A large and varied population of microorganisms, including the spores of many types of fungi, contaminates the surface of fruits during the growing season. Relatively few of the fungi are capable of attacking fruit before harvest. The ripening process increases the susceptibility of fruit to invasion. Fruits have a low pH that inhibits most bacteria. The acid-tolerant bacteria are mainly gram-positive Lactobacillus and Leuconostoc. Fruits are usually spoiled by acid-tolerant yeasts and molds.

b. **Soft Rot and Blue Mold Rot.** Penicillium species are important spoilage organisms of most fruits.

(1) Soft rot. P. digitatum and P. italicum cause soft rot in citrus fruit.

(2) Blue mold rot. P. expansum causes blue mold rot of deciduous fruit. Blue mold rot consists of soft, watery, tan to light brown areas that are readily gouged out of the flesh of the fruit. The tissue has a moldy or musty odor and flavor. There are typical bluish-green spores on the fruit. It is the most important storage decay of apples.

c. **Black Rot.** Black rot in apples, citrus fruits, bananas, and pineapples is due to species of Alternaria as well as other molds. The tissue becomes soft and watery.

d. **Brown Rot.** The brown rot of fruits has unsunken, decayed areas turning dark brown to black in the center. The mold spore masses are yellowish gray. The skin clings tightly to the center of the old lesion.

e. **Anthracnose.** Anthracnose is a defect with scattered black or dark brown sunken spots covering firm decayed tissue. With moist conditions, there are pink spore masses on the spots. Tomatoes are especially susceptible to this defect.

f. **Fungal Rot and Gray Mold Rot.** The loss of berries occurs with dehydration, discoloration, and overripe, mushy, damaged, moldy, or spoiled fruit. Common deteriorative conditions are fungal rot and gray mold rot. Berries are spoiled primarily by Botrytis and Mucor.

g. **Fermentation Defect.** The species of several genera of yeasts (Saccharomyces, Pichia, Torulopsis, and/or Candida) can cause a fermentation defect in fruits.

h. **Summary**. A summary of microbial conditions of fruits is found in figure 5-1.

FRUIT	CONDITION
Apples	Fermentation
Apricots	Gray mold rot
Bananas	Storage rot, Black rot, Crown rot
Berries	Fungal rot, Gray mold rot
Citrus fruit	Soft rot, Black rot
Fresh fruit, in general	Blue mold rot, Black mold rot, Souring, bitter flavor, Soft rot
Peaches	Brown rot
Muskmelons	Alternaria rot, Bacterial spot, Bacterial soft rot, Blue mold rot
Tomatoes	Blossom end rot, Bacterial spot, Late blight rot, Anthracnose, Soil rot, Sour rot
Watermelons	Anthracnose, Black rot, Stem-end rot

Figure 5-1. Microbial conditions of fruits.

5-3. MICROBIAL SPOILAGE OF FRESH VEGETABLES

a. **General.** Since vegetables are harvested from or near the soil, they are subjected to a mixed flora of soil, as well as airborne microorganisms. In general, the pH of vegetables is near neutrality, so that bacteria, as well as fungi, cause deterioration.

b. **Celery.** Celery plants are infected by strains of Sclerotinia sclerotiorum, which produce a pink rot at the base of the plant. The affected tissue is water soaked and soft, and the light-brown lesions have a pinkish-brown border.

c. **Cole Crops.** Brussels sprouts, cabbage, and cauliflower (cole crops of the crucifer family) are affected by Rhizopus soft rot. This fungus dissolves the infected tissue, rendering it mushy. The dead, light brown tissue is often covered by coarse, stringy mycelium that may bear masses of white to black clusters of spores.

d. **Lettuce.** There are several conditions that affect lettuce.

(1) Bacterial soft rot. Slime aptly describes this condition. It is caused by various species of bacteria. When the rot starts at or near the midrib, the first signs are small, yellowish-tan to rusty colored flecks or spots that enlarge and coalesce. As the disease spreads, the entire head may become a slippery brown mass.

(2) Downy mildew. Initially, the lesions tend to be small and confined to the upper surface of wrapper leaves. As the areas enlarge, they turn from light green or yellowish to brown and become soft.

(3) Watery soft rot. This rot occurs on the lower part of heads. The tissue is water soaked and light or pinkish brown. A white, cottony mold spreads over the decayed tissue, and the head eventually becomes a watery mass.

e. **Onions.**

(1) Bacterial soft rot. Onions may be affected by bacterial soft rot. The entire onion or individual fleshy scales are water soaked and pale yellow to light brown. Affected scales are soft and filled with putrid-smelling liquid. This liquid may ooze out at the neck when the upper part of the affected part is squeezed.

(2) Black mold rot. Black mold rot in onions is caused by Aspergillus niger. Black powdery spore masses adhere to the outer scale or are lodged between the two outer scales. The lesions will be sunken, discolored, and shriveled.

f. **Carrots.**

(1) Bacterial soft rot. Bacterial soft rot, due to Erwinia carotovora, is a problem in carrots. Lesions develop anywhere on the root, usually at injury sites. Lesions are soft, watery, and gray to brown. Advanced infections are slimy and have a putrid odor.

(2) Gray mold rot. Gray mold rot is a disease of stored carrots. Affected tissues are water-soaked, spongy, and light brown. Gray to brown mold and spore masses develop on the lesions.

g. **Potatoes.** Bacterial soft rot, due to Erwinia carotovora, is also a problem in potatoes. Soft rot enters tubers at bruised or heat-injured areas. Soft rot is at first light-colored, but with time and exposure to air, it becomes dark brown to black.

h. **Sweet Potatoes.** Black rot of sweet potatoes is due to Ceratocystis fimbriata. Most of the damage in the form of root decay occurs during storage. The early signs of black rot are round, slightly sunken spots. As the infection grows, the spots enlarge and become black to greenish black. Affected internal tissues are dark colored and have a bitter taste which affects the entire root when cooked.

i. A summary of microbial conditions of vegetables is found in figure 5-2.

VEGETABLES	VEGETABLES
Fresh vegetables in general	Soft rot, mushy, Black rot, soft, Black mold rot, Blue mold rot
Green beans	Anthracnose, Blight
Cabbage	Leaf spot, Gray mold
Carrots	Soft rot, Fungal rot, Wet rot
Celery	Fungal rot, Pink rot
Onions	Neck rot, Brown rot, Black mold rot
Potatoes	Ring rot, Dry rot

Figure 5-2. Microbial conditions of vegetables.

5-4. OVERVIEW OF MICROBIAL SPOILAGE OF FRESH FRUITS AND VEGETABLES

a. **General.** You, the inspector, will examine the product and note abnormal color(s), odor(s), and/or texture(s) and suspected microbial deterioration. You will identify the cause of these conditions.

b. **Causes.** Microbial spoilage may be caused by bacteria, mold, and/or yeast; however, microbial spoilage of FF&V is primarily due to mold.

c. **Color Changes.** The following external color changes are commonly associated with mold growth: blue, green, red, white, black, pink, and brown. These colors may be due to colonies of specific species of mold.

d. **Texture.** Microbial spoilage may cause the texture to become soft, mushy, water-soaked, slimy, dry, or hard.

5-5. MECHANICAL DAMAGE OF FRESH FRUITS AND VEGETABLES

a. **General.** Mechanical damage is due to the action of machinery, mishandling, and/or improper packaging, and may result in cuts, punctures, bruises, and/or abrasions. The fleshy fruits are very susceptible to mechanical damage. Product texture may be soft around any cut, puncture, or abrasion. Both internal and external examination of the product may be necessary to determine the extent of mechanical damage.

b. **Darkening in Color.** The following color change may indicate mechanical damage: a darkening in color of both external and internal tissues of the affected area.

c. **Improper Physical Handling.** Improper physical handling can result in injuries caused by impact, compression, abrasion, puncturing, tearing, or two or more such actions combined. Some FF&V items are more easily injured than others. Some show objectionable symptoms more readily. However, none of the items are immune to damage. Once damaged, the items lose value because they become discolored, unsightly, and prone to invasion by decay organisms.

(1) Impact damage. Impact damage occurs when an item hits a surface with sufficient force to damage or even separate its cell. The external sign is a bruise or a crack.

(2) Compression. Compression also causes bruising and cracking. Compression occurs primarily during or after packing as a result of forcing too much product into too small a container. While vegetables and melons should be packed firmly enough to avoid chafing, they should not be stuffed in so tightly that their curved surfaces become flat. This happens all too often with lettuce.

(3) Abrasion. Abrasions can occur:

(a) During harvest when roots or tubers are dug.

(b) When vegetables are conveyed at excessive speed.

(c) During packing.

(d) When tomatoes roll on dirty belts.

(e) During transit in slackly packed containers. Slackly packed containers permit the individual items to rub against each other or against the container surface.

(4) Puncturing. Puncturing is not a serious problem with most vegetables because the main contributor to puncture, the stem, is detached during harvest. However, punctures are sometimes sustained by cucumbers, eggplants, and some packs of tomatoes because their stems accidentally or unintentionally remain attached.

(5) Tearing. Tears are sustained by leafy vegetables and, because of the tissue exposed, contribute to rapid dehydration, discoloration, or decay of the affected leaf.

5-6. FREEZE INJURY OF FF&V

a. **General.** Freeze injury is exposure of the product to a temperature below the freezing point which results in formation of ice crystals and tissue injury. The extent of freeze injury will vary with the item, length of exposure, and temperature to which the product is exposed.

b. **Loss of Color.** A loss of color indicates freeze injury. Loss of color usually results in a glassy or transparent appearance.

c. **Texture.** Textural changes include softening and a water-soaked appearance. Usually, the outer layers of the product will peel. In some cases, the texture will be dry or parchment-like.

d. **Appearance.** Freezing injures vegetables and melons because ice crystals form in the cells and then rupture the cell walls. The damaged or dead cells lose their resistance to dehydration and to microbial infections. Further, freeze-damaged tissue loses its normal rigidity and becomes mushy upon thawing, leading to the water-soaked appearance commonly associated with thawed vegetables.

e. **Off-Odors.** Freezing also may lead to development of strong off-odors upon cooking the damaged vegetable. Broccoli is a serious offender because almost unnoticeable freeze injury to broccoli yields a very objectionable odor.

f. **Level of Resistance to Freeze Injury.** Figure 5-3 lists some vegetables according to their susceptibility to freeze injury. Unfortunately, the type of vegetable does not necessarily yield a clue to the susceptibility to freeze injury. Among leafy vegetables, lettuce is very readily injured, whereas cabbage is not. Green beans are readily damaged; green peas are not.

VEGETABLE	SUSCEPTIBILITY
Artichoke	High
Asparagus	High
Broccoli	High
Brussels sprouts	Fairly resistant
Cabbage	Moderate
Carrot	Moderate
Cauliflower	Moderate
Celery	High
Corn, sweet	High
Endive	Moderate
Green beans	High
Lettuce	High
Onions	Moderate
Peas	Moderate
Radish	Moderate
Spinach	Moderate
Turnip	Fairly resistant

Figure 5-3. Susceptibility of vegetables to freeze injury.

5-7. CHILL INJURY OF FF&V

a. **General.** Chill injury is exposure of the product to a temperature above its freezing point, but below the temperature normally recommended for storage of the item. The extent of the injury to the product will depend upon time and temperature.

b. **Susceptibility to Chill Injury.** Chill injury affects only certain vegetables, mainly those which had their origins in the tropics or in the subtropics. Susceptible plants that originated in temperate zones are dormant during the cold season.

c. **Signs of Chill Injury.** The signs of chill injury are as follows:

(1) Decay. Chilled vegetables decay readily because the low temperature reduces the resistance of cells to invasion by pathogens. Decay can spread rapidly in severely chilled vegetables because the pathogens are growing on dead or dying tissue.

(2) Discoloration. The discoloration may occur externally as in beans, or internally, as in eggplant. The spots or areas may be tan, brown, or black. They may become evident while the product is at low temperature or show primarily after transfer of the item to a nonchilling temperature. Internal discoloration may be noticeable immediately upon cutting the vegetable or only after the injured tissue has been exposed to air.

(3) Pitting. Pitting of the surface is an early symptom of chill injury. Under relatively dry conditions, the injured cells apparently lose moisture more rapidly than it can be transported to them. Desiccation then results in the collapse of the cells and the formation of pits.

(4) Abnormal ripening. The prevention of normal ripening caused by chill injury is seen in mature-green tomatoes and honeydew melons. In tomatoes, coloration is uneven. Desirable softening is delayed in both, and severe chilling may prevent the fruit from ever reaching an edible stage even if decay is absent. However, sensitivity to chilling decreases progressively in some fruits as they ripen, so that ripe tomatoes can tolerate low temperature more readily than pink fruits. In turn, the pinks can tolerate low temperatures better than mature-green fruits.

(5) Texture changes. The development of hard core in sweet potatoes is a texture change due to chill injury. This defect is characterized by the development of a mass of tissue that does not soften even upon cooking.

d. **Level of Resistance to Chill Injury.** Figure 5-4 lists the susceptibility of various vegetables and melons to chill injury.

PRODUCT	SUSCEPTIBILITY
Asparagus	Low
Banana	High
Lima bean	Moderate to low
Snap bean	Moderate to low
Cucumber	High
Eggplant	High
Cantaloupe	Low
Honeydew melon	High
Okra	Moderate
Bell pepper	Moderate
Potato	Low
Sweet potato	High
Tomato (ripe)	Low
Watermelon	Moderate

Figure 5-4. Susceptibility of vegetables and melons to chill injury.

5-8. DEHYDRATION

Dehydration, loss of water from the product, is usually due to improper storage conditions. In leafy vegetables, dehydration is evidenced by loss of turgor or wilted leaves. In nonleafy items, dehydration is evidenced by shriveled, wrinkled appearance.

5-9. FOREIGN MATERIAL

Foreign material is any extraneous matter which does not organically belong where found, which has been introduced from the outside, or which does not naturally occur in the quantity found at the location examined. This can include body parts from rodents and/or birds, excreta, chemical compounds, glass, and so forth.

5-10. DETERIORATION FROM UNKNOWN CAUSE

Examine the product for deterioration of unknown cause. If found, notify the veterinary officer. The veterinary officer will determine the cause of the condition, or he may have you prepare a sample of the product for submission to the medical laboratory.

5-11. DETERMINING THE AMOUNT, SEVERITY, AND EXTENT OF A DETERIORATIVE CONDITION

After you have determined the deteriorative conditions in fresh fruits and vegetables, determine the amount of deteriorative condition present in the product. You, the 91R20, will then determine the severity and extent of the condition. For this, you will use contractual documents or local SOP, as applicable. This information may have already been supplied by the 91R10 veterinary food inspection specialist's inspection reports.

Section II. DETERMINATION OF POTENTIAL HEALTH HAZARDS, RECOMMENDATIONS, AND REFERENCES

5-12. DETERMINATION OF POTENTIAL HEALTH HAZARDS

a. **Product Examination.** Determine the existence of any potential health hazard based upon type and amount of product deterioration. A health hazard is defined as any substance that could harm a person's health and/or well-being.

b. **Product Track Record.** Normally intact fresh fruits and vegetables present no health hazard unless contaminated by foreign material. However, research has shown that even fresh-cut produce can support rapid microbial growth.

5-13. RECOMMENDATIONS

a. **Inspector Action.** Utilizing all known information regarding the deteriorative fruits and vegetables, you will make recommendations concerning the product. Complete the appropriate forms and reports in accordance with local SOP.

b. **A Potential Health Hazard.** If you determine that a potential health hazard exists or is suspected to exist, notify the veterinary officer.

c. **Destination/Procurement Inspection.** If there is no potential health hazard found in a destination/procurement inspection, you must determine the compliance of the product based upon comparison of known information with information taken from the inspection data packet or local SOP.

d. **Surveillance Inspection.** If you find no health hazard on a surveillance inspection, you must determine serviceability after comparing known information with standards by DPSC or local SOP, as applicable. The following factors must be considered:

(1) Suitability for intended use.

(2) Expected usage date.

(3) Amount of product in storage.

(4) Storage environment.

e. **Disposition of Sample.** Following the determination of recommendations, you must determine the disposition of the sample. For further information, see subcourse MD0704, Inspection Records and Reports.

5-14. REFERENCES

The following references may be used in the determination of deteriorative conditions of fresh fruits and vegetables.

a. DOD 4145.19-R-1, Storage and Materials Handling.

b. AR 40-657, Veterinary Food Inspection.

c. DPSC Manual 4155.7, Subsistence In-Storage Quality Control and Inspection.

Continue with Exercises

EXERCISES, LESSON 5

Follow each set of instructions. After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the exercises and check your answers. For each incorrect answer, reread the material referenced after the answer.

INSTRUCTIONS. In exercises 1 through 5, match each microbial spoilage condition of fresh fruits and vegetables in Column A with the cause of that condition listed in Column B. Each cause in Column B may be used only once.

	COLUMN A		**COLUMN B**
1. ____	Black rot in apples.	a.	Penicillium.
2. ____	Soft rot in citrus fruits.	b.	Pichia.
3. ____	Pink rot in celery.	c.	Aspergillus.
4. ____	Fermentation of fruits.	d.	Streptococcus.
5. ____	Black mold rot in onions	e.	Alternaria.
		f.	Rhizopus.
		g.	Sclerotinia.

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or by writing the answer in the space provided.

6. Improper physical handling of fresh fruits and vegetables can result in injuries caused by:

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

7. Freeze injury (exposure of the product to a temperature below freezing) results in the formation of _____ _____ and _____ injury.

8. The signs of chill injury in fresh fruit and vegetables are:

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

INSTRUCTIONS. In exercises 9 through 14, match the vegetable in Column A with its susceptibility to freeze injury in Column B. Each susceptibility in Column B may be used more than once.

COLUMN A		**COLUMN B**
9. ____	Turnip.	a. High.
10. ____	Radish.	b. Moderate.
11. ____	Broccoli.	
12. ____	Lettuce.	c. Fairly resistant.
13. ____	Asparagus.	
14. ____	Celery.	

INSTRUCTIONS. In exercises 15 through 20, match the vegetable or melon in Column A with its susceptibility to chill injury in Column B. Each susceptibility in Column B may be used more than once.

	COLUMN A	COLUMN B
15. ____	Eggplant.	a. Low.
16. ____	Sweet potato.	b. High.
17. ____	Asparagus.	c. Moderate.
18. ____	Honeydew melon.	d. Moderate to low.
19. ____	Okra.	
20. ____	Cantaloupe.	

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or by writing the answer in the space provided.

21. Tomatoes are especially susceptible to:

    a. Brown rot.

    b. Fermentation defect.

    c. Gray mold rot.

    d. Anthracnose.

    e. Soft rot.

22. A common deteriorative condition of celery is:

    a. Bacterial soft rot.

    b. Black mold rot.

    c. Watery soft rot.

    d. Blight.

    e. Pink rot.

23. Select the genera that produces fermentation defect in fruits.

    a. Alternaria.

    b. Torulopsis.

    c. Penicillium.

    d. Botrytis.

    e. Rhizopus.

24. Which of the following is most affected by stem-end rot?

    a. Muskmelons.

    b. Bananas.

    c. Watermelons.

    d. Berries.

    e. Peaches.

25. Dry rot is a deteriorative condition most common to:

    a. Potatoes.

    b. Green beans.

    c. Carrots.

    d. Sweet potatoes.

    e. Cabbage.

26. Anthracnose is a microbial condition of all the following **EXCEPT**:

    a. Watermelons.

    b. Green beans.

    c. Tomatoes.

    d. Onions.

27. Select the genera that cause spoilage in berries.

    a. Pichia.

    b. Mucor.

    c. Sclerotinia.

    d. Saccharomyces.

    e. Leuconostoc.

28. All of the following vegetables are moderately susceptible to freeze injury **EXCEPT**:

    a. Spinach.

    b. Carrots.

    c. Peas.

    d. Cauliflower.

    e. Broccoli.

29. All of the following are moderately susceptible to chill injury **EXCEPT**:

    a. Snap beans.

    b. Okra.

    c. Cucumbers.

    d. Watermelons.

    e. Bell peppers.

30. Under improper storage conditions, which of the following is more likely to evidence loss of turgor?

    a. Lettuce.

    b. Eggplant.

    c. Green beans.

    d. Yams.

    e. Onions.

31. Which tomatoes tolerate low temperatures better?

    a. Mature-greens.

    b. Pinks.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 5

1. e (para 5-2c)

2. a (para 5-2b(1))

3. g (para 5-3b)

4. b (para 5-2g)

5. c (para 5-3e(2))

6. Impact.
   Compression.
   Abrasion.
   Puncturing.
   Tearing.
   Two or more actions combined. (para 5-5c)

7. ice crystals; tissue injury. (para 5-6a)

8. Decay.
   Discoloration.
   Pitting.
   Abnormal ripening.
   Texture changes. (para 5-7c)

9. c (figure 5-3)

10. b (figure 5-3)

11. a (figure 5-3)

12. a (figure 5-3)

13. a (figure 5-3)

14. a (figure 5-3)

15. b (figure 5-4)

16. b (figure 5-4)

17. a (figure 5-4)

18. b (figure 5-4)

19. c (figure 5-4)

20. a (figure 5-4)

21. d (para 5-2e)

22. e (para 5-3b; figure 5-2)

23. b (para 5-2g)

24. c (figure 5-1)

25. a (figure 5-2)

26. d (figures 5-1 and 5-2)

27. b (para 5-2f)

28. e (figure 5-3)

29. c (figure 5-4)

30. a (para 5-8)

31. b (para 5-7c(4))

End of Lesson 5

LESSON ASSIGNMENT

LESSON 6	Deterioration of Semiperishable Subsistence.
TEXT ASSIGNMENT	Paragraphs 6-1 through 6-11.
LESSON OBJECTIVES	After completing this lesson, you should be able to:
	6-1. Given a description of a deteriorative change in semiperishable subsistence, identify the condition and the cause of the change.
	6-2. Given a description of a deteriorative change in semiperishable subsistence, determine whether or not the presence of a health hazard exists.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 6

DETERIORATION OF SEMIPERISHABLE SUBSISTENCE

Section I. DETERIORATIVE CONDITIONS IN SEMIPERISHABLE SUBSISTENCE

6-1. INTRODUCTION

a. **Duty of a 91R20.** As a 91R20 veterinary food inspection specialist, you must verify the presence of deteriorative conditions in semiperishable subsistence. As appropriate, you will confirm the inspection findings which indicate the presence of deteriorative subsistence. Deteriorative conditions include abnormal color(s), off-odor(s), abnormal texture(s), off-color(s), foreign material, and so forth.

b. **Duty of a 91R10.** The 91R10 veterinary food inspection specialist's findings do not identify the deteriorative condition. Rather he notes abnormalities of inspected product that may indicate the presence of a deteriorative condition. These abnormalities may be of the packaging material (for example, swollen containers) or of the product itself.

c. **Importance of Normal Characteristics.** Due to the variability of semiperishable items, you must be familiar with characteristics exhibited by the normal product and use them as a standard to detect deteriorative conditions.

d. **Commercially Sterile Products.** In low-acid canned foods, the thermal process is enough to make the food commercially sterile. Commercial sterility of food means that heat is applied in such a way as to render such foods free of:

(1) Viable forms of microorganisms having public health significance.

(2) Other microorganisms of nonhealth significance but capable of reproducing in the food under normal nonrefrigerated storage and distribution.

6-2. SIGNS OF MICROBIAL DETERIORATION

a. **General.** You must identify the deteriorative conditions found in semiperishable subsistence. Examine the product noting abnormal color(s), odor(s), and/or texture(s) which may indicate microbial deterioration.

b. **Causes.** Microbial spoilage may be caused by bacteria, molds, and/or yeasts. The particular abnormalities involved will depend upon the type or species of microorganisms involved.

c. **Color Changes.** The color changes associated with microbial spoilage include white, green, brown, and/or black.

d. **Odors.** The following odors have been associated with microbial spoilage: sour, putrid, musty.

e. **Texture.** Textural abnormalities may include coagulation, liquefaction, and/or turbidity.

f. **Indicators of Spoilage in a Closed Container of Canned Foods.** Spoilage occurring in a closed container of canned foods is indicated by one or more of the following:

(1) Obvious gas production.

(2) Swelling of the lid of the container.

(3) A change in the texture/consistency of the product.

(4) A change in the pH of the product.

(5) An increase in the number of microorganisms seen in the microscopic examination of the food.

6-3. MICROBIAL SPOILAGE

a. **Spoilage in Low-Acid Foods.** The micrological groups associated with spoilage in low-acid foods (pH above 4.6) are as follows.

(1) Insufficient processing. Insufficient processing is indicated chiefly by the survival of bacterial spores, particularly those of the Clostridium species and those of the Bacillus species, which subsequently spoil the product. Generally, anaerobic mesophilic spoilage is associated with putrid odors.

(2) Storage at 110ºF or above. Low-acid foods may be spoiled during storage above 43ºC (109ºF) by a variety of extremely heat-resistant, sporeforming, thermophilic microorganisms. These bacteria are not pathogenic. In low-acid foods, the most common forms of thermophilic spoilage and the causative microorganisms are categorized as follows.

(a) Flat sour spoilage is indicated when the container is not swollen, and when the pH of the product is significantly lowered. The causative microorganisms are sporeformers, such as Bacillus stearothermophilus, a facultative anaerobe.

(b) Thermophilic anaerobe (TA) spoilage is indicated by swelling and, commonly, by the bursting of the container. The condition is caused by obligately thermophilic, sporeforming anaerobes such as Clostridium thermosaccharolyticum. This organism produces large quantities of hydrogen and carbon dioxide. The product usually has a "cheesy" odor.

(c) "Sulfide stinker" spoilage is characterized by a flat container in which the contents are darkened and have the odor for rotten eggs. This type of spoilage is caused by the sporeforming, anaerobic obligately thermophilic microorganism, Clostridium nigrificans. No swelling of the container is produced because the hydrogen sulfide is very soluble in the food. However, it does react with any iron present to form black iron sulfide.

b. **Spoilage in Acid Foods.** Micro-biological spoilage in acid foods is caused by microorganisms capable of growing at pH 4.6 or lower. Clostridium botulinum does not grow in these products unless abnormal conditions first produce a pH in excess of 4.6. Groups of microorganisms that may be associated with spoilage in acid foods (pH 4.6 or lower) are described as follows.

(1) Sporeforming microorganisms. A variety of acid-tolerant, sporeforming microorganisms may survive processing. They are as follows.

(a) Butyric anaerobes, such as the mesophilic, sporeforming anaerobe Clostridium pasteurianum, which produces butyric acid as well as carbon dioxide and hydrogen.

(b) Aciduric flat sours, especially Bacillus coagulans, in tomato products.

(c) Heat-resistant molds, particularly in the case of the contamination of juice concentrates and fruits by these fungi prior to processing. The causative microorganisms are usually Byssochamys fulva and related or similar species which produce very heat-resistant spores. Spoilage is evidenced by a moldy taste and odor, color fading, the presence of mold mycelia in the product, and sometimes slight swelling of the container lid.

(d) Yeasts and bacteria that do not reproduce by spores (asporogenous) may cause spoilage in cases of grossly insufficient processing. This type of spoilage may be indistinguishable from leaker spoilage unless the containers are thoroughly examined for leakage and structural defects.

(2) Thermophilic microorganisms. Thermophilic (high-temperature) spoilage may occur in acid foods, especially tomato products.

(3) Bacteria, yeast, and/or mold contaminants. Pure or mixed cultures of acid-tolerant bacteria, yeast, and mold contaminants are commonly found in leaker spoilage of acid products. The containers may be swollen or flat. Gas and swelling of the can is commonly produced by bacteria or yeasts and sometimes by molds. Spoilage in flat cans is caused by bacteria (rods and/or cocci) which do not produce gas. A slight lowering of the pH usually occurs. Mold spoilage usually is evidenced by the presence of mycelia and fungal spores in flat containers having a leak large enough to permit entrance of oxygen.

c. **Spoilage of Fruit Juices.**

(1) Flat or buttermilk flavor. The lactobacilli are important in the spoilage of fruit juices. Some strains are quite acid tolerant and can metabolize citric and malic acid. This reduces the acidity and results in a bland, rather flat flavor and a loss in astringency. A buttermilk flavor results in the fruit juice.

(2) Slimy consistency. Bacteria of the species Leuconostoc mesenteroides produces a slimy, unpleasant consistency of fruit juices.

(3) Fermentation. Yeasts contaminate and ferment fruit juice, especially apple juice. The sugars are fermented to alcohol which is converted to acetic acid, giving the fruit juice a vinegar flavor.

d. **Spoilage of Meat Products.** Canned meat products are subject to the same type of spoilage as other low-acid foods, if heat-resistant spores which survive the process can germinate and grow. In semipreserved or pasteurized cured products, such as canned ham, the curing salts and refrigeration are used to prevent spore germination and growth. If not adequately processed, thermoduric cells, such as Streptococcus faecium, may survive and cause souring. This organism may cause rapid discoloration after the product is removed from the can. If the spores of clostridia are able to germinate, gas may be formed along with extensive putrefaction.

e. **Spoilage of Salad Dressing.** The spoilage of mayonnaise and salad dressings is caused by Saccharomyces bailii and Lactobacillus fructivorans. Rather low numbers of the yeast and bacteria are present in the spoiled product.

f. **Spoilage of Tomato Juice.** Canned tomato juice is subject to flat sour spoilage if not properly handled either during preparation or final heat treatment. Flat sour spoilage is attributed to the presence of and growth of Bacillus coagulans, which either survives normal heat processes or recontaminates the product. Detection of spoilage is made by flavor, pH, and odor.

g. **Spoilage of Assorted Products.** Cereals, honey, molasses, syrup, and candy ordinarily have water activities too low to support the growth of bacteria. However, due to storage at high relative humidity or production of water by metabolism, bacteria can be responsible for the spoilage of these products.

h. **Spoilage of Bottled Sauces.** The gas-forming Lactobacillus lycopersici causes fermentation in tomato catsup, other tomato products, Worcestershire sauce, and similar products.

i. **Spoilage of Canned Peaches and Pineapple.** Canned pineapple occasionally exhibits spoilage caused by gas-formers, Leuconostoc mesenteriodes. This organism may also cause ropiness in canned peaches.

j. **Spoilage of Packaged Milk.** Occasionally, heat-resisting, anaerobic bacteria cause trouble in milk packs. The anaerobes produce off-flavors, thinning, curdling, and so forth, in canned milk.

k. **Summary.** Figure 6-1 is a summary of microbial conditions found in semiperishable subsistence.

PRODUCT	CONDITION
Canned fruit	Butyric acid, Soft rot
Canned apricots	Softening
Canned grapefruit	Gas ($C0_2$)
Fruit juice	Souring, $C0_2$ Acetification (production of acetic acid or vinegar} Moldy surface, Cloudy, Buttermilk flavor
Jelly, jam preserves	Fermentation, moldy
Canned corn, green beans, peas	Flat sour, Sulfide stinker, Putrid swell, Hard swell
Canned tomatoes	Flat sour, Butyric fermentation
Pickles	Soft, Black, Soft, mushy, slimy, Reduced acidity
Sauerkraut	Pink
Vegetable juice	Sour
Bread	Ropy, slime, Black mold, Blue mold, Pink mold, Sour, Red
Cereals, grains	Moldy, Discoloration, Pink
Honey	Fermented, yeasty
Molasses	Gas, frothy
Canned meat	Gas, souring, putrefaction, discoloration

Figure 6-1. Microbial conditions of semiperishable subsistence.

6-4. OXIDATIVE RANCIDITY

a. **General.** Examine the product and note any color, texture, flavor, and/or odor abnormalities. Check for the presence of oxidative rancidity.

b. **Characteristics.** Oxidative rancidity is caused by oxidation of unsaturated fats. Products with a high degree of unsaturated fats are most susceptible to oxidative rancidity. In freeze-dehydrated items, the rancidity will be in the lean rather than the fat component of the food item.

c. **Odor and Flavor.** The odor is acrid, sharp, and biting. A rancid flavor may be present and will vary depending on the stage of reaction.

d. **Reference.** A discussion of oxidative rancidity may be found in paragraph 1-14a.

6-5. CHANGES IN TEXTURE

a. **General.** Changes in the texture of the product caused by physical changes may include brittleness, friability, crumbling, hardening, caking, coagulation, lack of crispness, liquefaction, evaporation, turbidity, separation, sedimentation, and crystallization.

b. **Brittleness/Friability/Crumbling.** These texture changes are related to loss of moisture over a period of time.

c. **Hardening.** This change may be due to chemical reactions, improper ingredient formulation, or loss of moisture.

d. **Caking/Lack of Crispness.** This is a result of a gain in moisture.

e. **Coagulation.** This change is due to pH changes and/or high temperatures.

f. **Liquefaction.** This texture change is the breakdown of a solid or gel product into a liquid state. Liquefaction is basically caused by an increased temperature.

g. **Evaporation.** Evaporation is the loss of moisture from the product due to improper storage conditions.

h. **Turbidity/Sedimentation.** This change is due to breakdown of the product due to improper storage. Sedimentation is evidenced by the presence of solid particles separating out in a fluid medium. Turbidity is associated with incomplete sedimentation of solid particles resulting in a cloudiness of the fluid media.

i. **Separation.** Separation is due to storage of a product at high temperatures and usually occurs in emulsified products such as salad dressing. The product breaks down into several components.

j. **Crystallization.** This is a formation of crystalline objects not normally found in a product. It is due to high temperatures and improper product formulation.

6-6. FOREIGN MATERIAL

Foreign material is any extraneous material which does not organically belong where found, which has been introduced from the outside, or which does not naturally occur in the quantity found at the location examined. This can include body parts from rodents and/or birds, excreta, chemical compounds, glass, oil, sawdust, wood, and so forth.

6-7. DETERIORATION FROM UNKNOWN CAUSE

Examine the product for deteriorative changes. If the changes have been identified but a cause is not known, notify the veterinary officer. The veterinary officer will determine the cause of the condition. If the cause cannot be determined, then the veterinary officer will have you prepare a sample of the product for submission to the medical laboratory. For further information, see subcourse MD0704, Inspection Records and Reports.

6-8. DETERMINING THE AMOUNT, SEVERITY, AND EXTENT OF A DETERIORATIVE CONDITION

Following the determination of the deteriorative conditions in semiperishable subsistence, determine the amount of deterioration present in the product. You, the 91R20, will determine the severity and extent of the condition utilizing contractual documents or local SOP, as applicable. This information may have already been supplied by the 91R10 veterinary food inspection specialist's inspection reports.

Section II. DETERMINATION OF POTENTIAL HEALTH HAZARDS, RECOMMENDATIONS, AND REFERENCES

6-9. HEALTH HAZARDS IN SEMIPERISHABLE SUBSISTENCE

a. **General.** Determine the existence of any potential health hazard, based upon the type and amount of product deterioration. A health hazard is defined as any subsistence that could harm a person's health and/or well-being.

b. **Oxidative Rancidity.** If this condition is present in severe quantities, a potential health hazard may exist. For a discussion on the potential health hazard of oxidative rancidity in foods, see paragraph 1-14.

c. **Microbial Spoilage.** Depending upon the microorganisms present in the product, microbial spoilage may certainly be a potential health hazard.

(1) Characteristics of botulism contamination. Food poisoning types of other than Clostridium botulinum are rarely found in canned foods. Clostridium botulinum has been the cause of many deaths from consumption of home-canned foods. Since commercial heat processes are regulated by FDA and USDA, the problem is very rare in commercially canned foods. In addition to its deadly toxin, Clostridium botulinum normally produces gas from most sugars (and thus swells the container) or digests the low-acid canned food. Therefore, the person opening the container has some indication of its presence. When an odor is produced, it is putrefactive, not fecal or sour, but sickening.

(2) Other potential contaminants. Other food poisoning types are extremely rare and have not been found in commercially canned foods in the US. Salmonellae and staphylococci produce no spores to survive heating and are therefore of no consequence in commercially canned foods. While Clostridium perfringens and Bacillus cereus produce spores, they have very little heat resistance in comparison with the spore-forming spoilage types. In addition, since Clostridium perfringens is a profuse gas producer, it would burst most containers of canned foods.

d. **Foreign Material.** Foreign material must exceed certain formal guidelines to present a potential health hazard. The type of foreign material found on the product will also determine the health hazard potential.

e. **Deterioration From Unknown Cause.** If the cause for a deteriorative condition is unknown, the veterinary officer will make the decision as to whether a potential health hazard is present or not.

6-10. RECOMMENDATIONS

a. **Inspector Actions.** Utilizing all known information regarding the deteriorative semiperishable items, you will make recommendations concerning the product. Complete the appropriate forms and reports in accordance with local SOP.

b. **A Potential Health Hazard.** If you determine that a potential health hazard exists or is suspected to exist, you must notify the veterinary officer.

c. **Destination/Procurement Inspection.** If you find no potential health hazard in a destination/procurement inspection, you must determine the compliance of the product based upon comparison of known information with information taken from the inspection data packet or local SOP.

d. **Surveillance Inspection.** If you find no health hazard on a surveillance inspection, you must determine serviceability after comparing known information with standards by DLA 4155.37, Appendix S; DPSC Manual 4155.7; AR 40-656; or local SOP as applicable. The following factors must be considered:

(1) Suitability for intended use.

(2) Expected usage date.

(3) Amount of product in storage.

(4) Storage environment.

e. **Disposition of Sample.** Following the determination of recommendations, you must determine the disposition of the sample. For further information, see subcourse MD0704, Inspection Records and Reports.

6-11. REFERENCES

The following references may be used in the determination of deterioration of semiperishable subsistence.

a. AR 40-656, Veterinary Surveillance Inspection of Subsistence.

b. AR 40-657, Veterinary Food Inspection.

c. DLA 4155.37, Appendix S, Quality Control Depot Serviceability Standards.

Continue with Exercises

EXERCISES, LESSON 6

INSTRUCTIONS. The following exercises are to be answered by marking the lettered response that best answers the question or best completes the incomplete statement or by writing the answer in the space provided. Follow special instructions for matching items.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each incorrect answer, reread the material referenced after the answer.

1. Low-acid foods are defined as foods with a pH:

   a. Of 4.5.

   b. Below 4.6.

   c. Above 4.6.

   d. Of 7.0.

2. Bacterial spores survive insufficient processing. The resultant spoilage is due to spores of _____ species and _____ species.

   a. Pseudomonas and Proteus.

   b. Bacillus and Clostridium.

   c. Bacillus and Penicillium.

   d. Clostridium and Lactobacillus.

3. In low-acid foods, the most common forms of thermophilic spoilage and the causative microorganisms are:

   a. _____ due to _____.

   b. _____ due to _____.

   c. _____ due to _____.

4. Define commercially sterile. It is the condition achieved by application of _____ in such a way as to render food free of:

   (1) _____ _____of microorganisms having _____ _____ significance and

   (2) other microorganisms of _____significance but capable of _____ in the food under normal nonrefrigerated storage and distribution.

5. When spoilage occurs in a closed container of canned foods, one may observe the following changes:

   a. _____.

   b. _____.

   c. _____.

   d. _____.

   e. _____.

6. Acid foods are defined as foods with a pH:

   a. 4.6 or lower.

   b. 4.6 or above.

   c. Equal to 7.0.

   d. Of 4.5.

7. All of the following microorganisms will grow at a pH of 4.6 or lower except:

   a. Bacillus coagulans.

   b. Clostridium pasteurianum.

   c. Byssochamys fulva.

   d. Clostridium botulinum.

8. During the inspection of canned apple juice, you notice a slimy, unpleasant consistency. This condition is probably due to:

   a. Lactobacillus species.

   b. Streptococcus pyogenes.

   c. Leuconostoc mesenteroides.

   d. Bacillus thermus.

9. If canned hams are not adequately processed, souring of the product may be due to:

   a. Streptococcus aureus.

   b. Streptococcus faecium.

   c. Bacillus species.

   d. Staphylococcus aureus.

10. Canned tomato juice is subject to flat sour spoilage due to:

    a. Bacillus bailii.

    b. Clostridium perfringens.

    c. Streptococcus coagulans.

    d. Bacillus coagulans.

11. The spoilage of mayonnaise and salad dressing is caused by _____

    _____ and _____.

INSTRUCTIONS. In exercises 12 through 15, match the product in Column A with the microbial condition in Column B. Each microbial condition in Column B may be used only once.

COLUMN A	COLUMN B
12. ____Sauerkraut	a. Ropy.
13. ____Canned apricots.	b. Butyric fermentation.
14. ____Fruit juice.	c. Putrid swell.
15. ____Bread.	d. Buttermilk flavor.
	e. Yeasty.
	f. Softening.
	g. Pink color.

INSTRUCTIONS. In exercises 16 through 20, match the texture change in Column A with its cause in Column B. The cause in Column B may be used more than once.

COLUMN A	COLUMN B
16. ____Caking.	a. Breakdown due to improper storage.
17. ____Friability.	b. Microorganisms.
18. ____Coagulation.	c. Loss of moisture.
19. ____Sedimentation.	d. High temperature.
20. ____Crystallization.	e. Freezing.
	f. Gain in moisture.
	g. Chill injury.

21. In which of the following is an inspector more likely to find pink, blue, or black mold?

    a. Bread.

    b. Cereals.

    c. Jelly, jam, or preserves.

    d. Pickles.

    e. Honey.

22. Sulfide stinker spoilage cannot be identified by swelling of a container. In which of the following is the inspector more likely to find this condition?

    a. Canned fruit.

    b. Canned meat.

    c. Canned tomatoes.

    d. Canned corn.

    e. Canned grapefruit.

23. What microorganism causes fermentation in bottled sauces and in tomato products such as catsup?

    a. Bacillus stearothermophilus.

    b. Saccharomyces bailii.

    c. Lactobacillus lycopersici.

    d. Clostridium pasteurianum.

    e. Lactobacillus fructivorans.

24. Butryric fermentation is more likely to be found in:

    a. Canned grapefruit.

    b. Fruit juice.

    c. Canned green beans or green peas.

    d. Molasses.

    e. Canned tomatoes.

25. Thermophilic anaerobe (TA) spoilage is indicated by swelling and, commonly, by the bursting of the container. An example of such a sporeforming microorganism is:

    a. Clostridium thermosaccharolyticum.

    b. Byssochamys fulva.

    c. Clostridium perfringens.

    d. Bacillus stearothermophilus.

    e. Bacillus cereus.

26. Select the change in texture that usually occurs in emulsified products and is due to storage at high temperatures.

    a. Liquefaction.

    b. Separation.

    c. Coagulation.

    d. Sedimentation.

    e. Crystallization.

27. Select the change in texture of a product that results from the loss of moisture due to improper storage conditions.

    a. Crumbling.

    b. Hardening.

    c. Lack of crispness.

    d. Evaporation.

28. Select the change in texture of a product that is the result of a gain in moisture.

    a. Brittleness.

    b. Sedimentation.

    c. Crystallization.

    d. Liquefaction.

    e. Caking.

29. If an inspector opens a container that has botulism contamination, the odor that is produced is:

    a. Putrefactive.

    b. Sour.

    c. Fecal.

    d. That of rotten eggs.

30. Veterinary Surveillance Inspection of Subsistence is the title of:

    a. AR 40-657.

    b. DPSC Manual 4155.7.

    c. AR 40-656.

    d. LA 4155.37, Appendix S.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 6

1. c (para 6-3a)

2. b (para 6-3a(1))

3. a. Flat sour spoilage; Bacillus stearothermophilus.
   b. TA spoilage; Clostridium thermosaccharolyticum.
   c. Sulfide stinker; Clostridium nigrificans.
   (para 6-3a(2))

4. heat; (1) viable forms; public health;
   (2) nonhealth; reproducing (para 6-1d)

5. Gas production.
   Swelling of the lid of the container.
   Change in the texture.
   Change in pH of product.
   Increase in number of microorganisms. para 6-2f)

6. a (para 6-3b)

7. d (para 6-3b)

8. c (para 6-3c(2))

9. b (para 6-3d)

10. d (para 6-3f)

11. Saccharomyces bacilli; Lactobacillus fructivorans (para 6-3e)

12. g (figure 6-1)

13. f (figure 6-1)

14. d (figure 6-1)

15. a (figure 6-1)

16. f (para 6-5d)

17. c (para 6-5b)

18. d (para 6-5e)

19. a (para 6-5h)

20. d (para 6-5j)

21. a (figure 6-1)

22. d (figure 6-1)

23. c (para 6-3h)

24. e (figure 6-1)

25. a (para 6-3a(2)(b)

26. b (para 6-5i)

27. d (para 6-5g)

28. e (para 6-5d)

29. a (para 6-9c(1))

30. c (para 6-11a)

End of Lesson 6